The processing and representation of the bilingual Chinese-English mental lexicon

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Awarding institution:
King's College London

Title: The processing and representation of the bilingual Chinese-English mental lexicon

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by

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Thesis written under the supervision of

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submitted for the degree of Doctor of Philosophy

at the

Department of Education and Professional Studies

King's College London

1st May 2013

”Actually, thinking is most mysterious, and by far the greatest light upon it that we have is thrown by the study of language”

Benjamin Lee Whorf

(1956 [1942]:252)

to my family
to my friends
to all the exceptional people around me
to the amazing last three years that were rich in knowledge
new experiences, challenges and joy
to me for not giving up on the pursuit of knowledge and happiness
to the start of my career in academia
and to all the wonderful things to come
I am looking forward to it

ACKNOWLEDGEMENTS

There are many people who I would like to say thank you to. First and foremost, I would like to thank my two supervisors at King's College, London, Dr. Gabriella Rundblad and Dr. Jill Hohenstein for their valuable comments, for being critical of my work but at the same time supportive. Also, I would like to thank them for the numerous reference letters that they were requested to write and for giving me the opportunity to learn about marking students work and organizing a successful conference.

Furthermore, I would like to thank several people that were involved in the process of designing my study. I would like to send a big thank you all the way to Singapore to Junqing Zhai, TJ, who not only helped me translate all English forms and questionnaires into Chinese but also agreed to be recorded for the auditory priming task. Also, I would like to thank Chris Tang who agreed to be the English voice in the auditory task. I cannot say enough thank you to my friend Niki Chan who verified the translation lists and who was always there for me in Hong Kong.

There are actually a number of people in Hong Kong, whom I would like to extend my thanks to. First of all, I would like to thank Prof. Peter Kutnick who helped me arrange the visit to Hong Kong and welcomed me warmly at the HKU. Second, I would like to send my thanks to Ada Cheung, who was extremely helpful during my entire stay at the HKU. Next, I wish to thank Prof. Brendan Weekes who offered his expertise and gave me a number of useful suggestions regarding my study and also introduced me to the Communication Science Lab at the HKU. Finally, I would warmly like to thank all my participants from the HKU, the CUHK, from King's College in London, and from the

China University of Geosciences in Beijing, without whom it would not be possible to conduct this research.

Furthermore, I would like to send huge thank you to the foundations/associations that helped me financially during the last three years. The Allan and Nesta Ferguson Charitable Trust, Universities' China Committee in London, and British Association of Applied Linguistics are those foundations/associations that I wish to thank the most.

Finally but not lastly, I would like to thank all my wonderful friends from London, Cambridge, Hong Kong, Australia, and Poland. All of you have been a great support to me not only in the last three years but throughout the last thirty years of my life, often despite distance, and I cannot thank you enough for that. I would like to address my very special thanks to Anastasia Ulicheva for being a fabulous friend and a great researcher. My stay in Hong Kong would never be so memorable if it was not for your company! I also wish to thank the very special friend JinA Kim who is the warmest and the most considerate person that I have ever known. Furthermore, I would like to thank the wonderful and caring Sebastian Krautz. Thank you for believing in me, for teaching me so many things and for being there for me every single day! Finally, I want to thank my family in Polish.

Dziękuję mojej mamie Eli, mojemu świętej pamięci tacie Kazikowi, mojej siostrze Ani, siostrzenicy Hani, szwagrowi Rajmundowi, babci Alwince i pozostałym członkom rodziny za wspieranie mnie, za pomoc, za troskę, za to, że pomogli mi stać się tym człowiekiem, którym jestem dziś! Dziękuję wam z całego serca!

Dziękuję / Thank you / 谢谢

ABSTRACT

This study investigated the representation and processing of the bilingual Chinese-English mental lexicon. Specifically, the conceptual level of representation was examined. Four aims were pursued in this project. First and second, this investigation addressed the way in which concepts are represented and processed in bilingual lexical memory. It also compared language processing on a word level in visual and auditory modalities. Finally, the investigation probed the degree of semantic overlap in bilingual speakers. To achieve the aims of this project, Chinese-English speakers were requested to perform a primed animacy decision task. This task allowed for the addressing of the notions of priming effect, priming asymmetry effect, and the impact of modality on language processing. In addition, bilingual participants and control groups of monolingual English and Chinese participants were requested to take part in a semantic judgment task. This task was used to evaluate the notion of semantic overlap. The investigation of the four separate notions helped test the Revised Hierarchical Model (RHM) (Kroll and Stewart, 1994). It was demonstrated that participants responded more rapidly to the related targets (translation equivalents) than to the unrelated ones (words in L1 and L2 that did not share meaning) and this was taken as evidence for a shared conceptual store. Moreover, a priming effect was observed from L1 to L2 but it failed to appear in the L2 to L1 language direction. This pointed to a priming asymmetry and the fact that the strength of the interlexical connection between L1 and concepts is stronger than this relationship with L2. Further comparison of the results from the visual and auditory modalities illustrate that the processes are not identical and that the information in the two modalities might become available at slightly different rates. Finally, a comparison of bilingual and monolingual semantic structures revealed that bilingual English and Chinese conceptual maps are more similar to one another than to the

monolingual English or Chinese maps, respectively, which in turn may point to the process of *semantic convergence* (Pavlenko, 2009). The findings obtained in this study substantiate the original framework of the RHM (Kroll and Stewart, 1994).

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

A	auditory modality
ANOVA	analysis of variance
AoA	age of acquisition
BIA / BIA+	Bilingual Interactive Activation Model / Bilingual Interactive Activation + Model
C	concepts
Cc	common concepts
C1	L1 conceptual store
C2	L2 conceptual store
CUHK	the Chinese University of Hong Kong
DFM	Distributed Feature Model
ER	error rate
ERs	error rates
EEG	electroencephalography
ERP	event-related brain potential
FA	factor analysis
FL	foreign language
fMRI	functional magnetic resonance imaging
HKU	the University of Hong Kong
IELTS	International English Language Testing System
KMO	Kaiser-Meyer-Olkin value
L1	first language
L2	second language
L3	third language
LDT	lexical decision task
LoE	length of exposure
MDS	multidimensional scaling
MEG	magnetoencephalography
MHM	Modified Hierarchical Model

ms	milliseconds
NIRS	near infrared spectroscopy
NWR	nonword ratio
OR	omission rate
PET	positron emission tomography
RHM	Revised Hierarchical Model
r	related
RP	relatedness proportion
RT	reaction time
RTs	reaction times
SAM	Shared (distributed) Asymmetrical Model
SLA	second language acquisition
SLL	second language learning
SOA	stimulus onset asynchrony
SPSS	Statistical Package for Social Sciences
TMS	transcranial magnetic stimulation
u	unrelated
WEAVER++	Word Encoding by Activation and Verification ++ Model
V	visual modality

LIST OF SYMBOLS

d	distance
F_1	subject analysis
F_2	item analysis
M	mean
N	number of participants per experiment
n	number of observations per condition per participant
p	p-value
SD	standard deviation
t	t-test

CHAPTER ONE

INTRODUCTION

The contemporary world is characterised by growing linguistic and cultural diversity. Knowledge of two or more languages is no longer considered in terms of necessity, but rather obviousness. That is, bilingualism is so widespread nowadays, that it is no longer considered to be an exception, but a norm (Grosjean, 1998). Many people, from the day they are born, are brought up in two languages simultaneously. Many others acquire two or more languages early in life in order to be able to keep up with the pace of the modern world. Great mobility, linguistic imperialism of the English language as well as development of information technologies offer numerous opportunities for self-growth and self-actualization, but at the same time force us constantly to upgrade our qualifications and language skills. Furthermore, the status of English language as a lingua franca is globally accepted and many people apart from speaking their native language use English to a varying degree. However, in recent years a tendency has been observed for one another language to play an increasingly significant role in international communication, namely Mandarin Chinese. This change is directly related to the rapid growth of Chinese economy and it could well result in a shift of the importance of the different languages around the world.

The fact that more people around the world are bilingual rather than monolingual (e.g. Bialystok et al., 2012; Grosjean, 1989) as well as the importance of both English and Chinese languages motivated this researcher to carry out an investigation with Chinese-English bilingual participants. Moreover, these two languages were chosen since the "Chinese writing system presents a sharp contrast to English and other alphabetic writing systems" (Tan et al., 2000:16), and thus such an investigation offers valuable insights into the knowledge of both language-specific cognitive processes and universal properties of memory models developed on the basis of Indo-European languages (Zhou et al., 2009:148).

1.1 Focus of the study

The organisation of the bilingual mental lexicon, which can be likened to a dictionary or a database of all words stored in the mind of a language user (Dijkstra, 2005), has proved to be one of the most controversial topics in the field of bilingualism (Pavlenko, 2009). After more than sixty years of research, a conclusion still has not been reached as to whether two languages in a bilingual lexical memory are stored together or separately. Many researchers agree on a separate lexical level of representation (orthography, phonology) but no conclusion has yet been reached regarding the conceptual level of representation. Empirical evidence supporting a fully integrated conceptual representation (Kroll and Stewart, 1994; Potter et al., 1984) as well as a distributed representation (de Groot, 1995; Dong et al., 2005; Finkbeiner et al., 2004; Pavlenko, 2009) has been demonstrated. Furthermore, numerous models of the structure of bilingual lexical memory have been proposed, notably the Revised Hierarchical Model (RHM) (Kroll and Stewart, 1994) that is investigated in this project. The proponents of this model propose separate lexical representations for each of two languages, but one common conceptual representation for both languages. If there, indeed, is a common store, then word meanings can be accessed via two different processing routes: directly or translated from the other language. In turn, the choice of route influences the speed of language processing. The two notions of bilingual lexical representation and language processing are investigated in this study.

1.2 Aims of the study

The present study has four aims. The first is to clarify the way in which meanings of translation equivalents are represented in Chinese-English bilingual memory. Second, there is goal of examining the processing of information stored at the conceptual level. The third aim is to widen the scope of findings by focusing on both auditory and visual modalities of word recognition, as a window for investigating the bilingual memory organisation. Finally, there is the intention to provide a greater understanding of the representation of the Chinese-English bilingual memory by looking at the degree of the semantic overlap between the two languages. The four aims have been formulated into four separate hypotheses that are tested through this study. First, the notion of shared versus separate semantic representations is under investigation. Secondly, the representational account outlined by the RHM (Kroll and Stewart, 1994) is tested. Also, the visual and auditory modalities of word recognition are compared and their impact on bilingual memory organisation is analysed. Finally, the degree of semantic overlap between the two languages is examined.

1.3 Methods employed in the study

Four main research tools are used to recruit participants and collect data in this project, i.e. a bilingual questionnaire, a monolingual questionnaire, a masked priming experiment (visual and auditory) and a semantic judgement task. The bilingual questionnaire is used to select a group of bilinguals between the age of 18 and 25 who were dominant in Mandarin Chinese. In addition, it is aimed at establishing the type of bilingualism, language history, English language ability and language preference. The information collected from the monolingual questionnaire helps in the choosing of monolingual English and Chinese participants who act as controls for the semantic judgment task. That is, the questionnaire is used to establish if the participants are native speakers of English or Chinese and if they are monolingual. Moreover, the masked priming paradigm in the form of a primed animacy decision task is used to explore how words are stored and connected in memory (Altarriba and Basnight-Brown, 2009). This paradigm is used to address the first three hypotheses of this project, whereas the semantic judgment task is administered to address the fourth one. The data from this task is analysed with the use of multidimensional scaling analysis and it allows for producing a spatial representation of the semantic relationship (Herrmann and Raybeck, 1981) between selected translation equivalents in Chinese and English.

1.4 Significance of the study

So far, a great majority of the bilingual memory representation studies have focused on a comparison of Indo-European languages, taking into account the common origin of the languages and similarities that can be found in the given systems. A number of studies compared Dutch-English participants (e.g. de Groot and Poot, 1997; Kroll and Stewart, 1994; van Hell and de Groot, 1998), Spanish-English participants (e.g. Altarriba, 1992), Catalan-Spanish participants (e.g. Duñabeitia et al., 2010; Guasch et al., 2011), Dutch-French participants (e.g. Duyck and Warlop, 2009a) and French-English participants (e.g. Smith, 1991; Williams, 1994), but few researchers have paid attention to a comparison of such distinct linguistic systems as Chinese and English. Comparative studies carried out by e.g. Dong et al. (2005), Jiang (1999), Jiang and Forster (2001), Li et al. (2009), Wang and Forster (2010) and Wang (2013) can be found among those few that investigated the lexical memory representation of Chinese-English bilinguals. Nevertheless, these previous studies have so far been limited to visual word recognition, despite the conspicuous difference in scripts between English and Chinese, which could have pushed participants into a bilingual mode (Grosjean, 1998) and hence skewed the results.

In order to overcome this obstacle and to extend the scope of the findings for this research visual as well as auditory stimuli are employed.

1.5 Originality of the study

The originality of this project lies in the pair of languages investigated, in the visual and auditory modalities researched, and in the combination of the research methods employed to investigate the bilingual mental lexicon. This study is probably the very first to use the auditory masked priming paradigm with Chinese-English bilinguals and most likely the first to employ cross-language auditory priming. This research tool has been used before by other researchers, however, primarily it was administered to groups of monolingual participants. Furthermore, this investigation is one of a few that uses an implicit conceptual memory task, i.e. the animacy decision task to examine the representation of the conceptual level of information in bilingual speakers. That is, the great majority of the bilingual representation studies used a lexical decision task (LDT)[1] to investigate the conceptual memory organisation without acknowledging that an LDT relies on shallow processing, i.e. on processing of the physical features of words rather than on processing the actual meaning of words (deep processing). Finally, this project, by employing the multidimensional scaling technique, takes our understanding of the bilingual mental lexicon a step further. More specifically, not only does this thesis provide an account of whether the two languages are stored separately or together in memory but also it reports on the degree of semantic overlap between Chinese and English.

[1] In a lexical decision task participants are requested to recognise if a presented string of letters is an example of a word or a nonword.

1.6 Educational implications

If bilinguals have a shared conceptual store, then "L2 [teaching/learning] instruction should focus on strengthening the links between L2 words and their L1 translation equivalents" (Pavlenko, 2009:154). However, if the store is not shared, i.e. if the concepts are language/culture specific, then apart from acquiring the orthography, phonology and morphology, one has to create a new meaning when learning L2 (Jiang, 2000). To achieve this, a different set of teaching/learning instructions should be employed, e.g. use of concrete examples, realia, discussion, and working with definitions. Therefore, to understand the specific learning needs of bilingual Chinese-English speakers, one has to first of all understand how the information is stored and processed in the bilingual memory. The choice of teaching methods might be related to the representation of concepts in the mental lexicon. Hence, this study addresses the educational implications that might be arising from the specific 'architecture' of the bilingual conceptual level of representation as outlined by the RHM (Kroll and Stewart, 1994).

1.7 Organisation of the thesis

This thesis is organised into eight chapters. The literature review is presented in chapter two. In particular, notions of bilingualism, bilingual mental lexicon, and conceptual store are of major focus. Also, a comparison between English and Chinese languages is made and the notion of a priming effect as well as the notion of a semantic structure of a chosen semantic domain is discussed. Next, chapter three outlines the research methods employed in this study. Detailed information about the participants, the stimuli, the design of the tasks, and ethical consideration is also included. Chapter four is fully devoted to the presentation and analysis of the results obtained in this study, results which are then comprehensively discussed in chapter five. Here, the hypotheses examined in this study are addressed one at a time, the RHM is tested, and the limitations of the methods used are discussed. The remaining chapters, i.e. chapters six, seven and eight focus, respectively, on implications (ecological validity, a framework for research in the mental lexicon (Libben and Jarema, 2002) and educational implications of the memory models), future research, and conclusions.

CHAPTER TWO

LITERATURE REVIEW

This chapter illustrates the breadth of the extant research on the representation and processing of the bilingual lexical memory, which in turn will help in the development of the conceptual framework of this study. The discussion in this chapter begins by defining the phenomena of bilingualism, bilingual mental lexicon[2] and conceptual store[3]. Then, the focus is on the choice of languages studied, i.e. Chinese and English, regarding which some similarities as well as differences will be delineated. Next, the discussion revolves around the selection of the masked priming paradigm as the most suitable experimental design for the purpose of this study. Finally, after consideration of the choice of modality and the semantic judgment task, this chapter ends with a presentation of the aims of this project and the hypotheses that were tested.

2.1 Bilingualism

When defining a bilingual person, there are numerous components that have to be taken into consideration. However heterogeneous the group of bilinguals may seem, apart from the fact that they use more than one language in their everyday life, there are numerous other aspects that distinguish such individuals. Among the differentiating components are: bicultural experience, education and literacy in either language, age of acquisition, context and purpose of language use. Despite the need to account for so many differentiating elements, there have been a number of definitions proposed that accurately encapsulate the notion of bilingualism. For instance, based on the notion of

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[2] *Bilingual mental lexicon*, *bilingual lexical memory*, *bilingual lexicon*, and *bilingual memory* are terms that are used interchangeably in this thesis.

[3] *Conceptual store*, *conceptual representation*, and *semantic representation* are terms that are used interchangeably in this thesis.

critical period, Lambert (1985) differentiated between early (before the age of six) and late (after the age of twelve) bilingualism. This distinction was made on the grounds of the belief that the human brain possesses certain flexibility that is biologically founded. As the brain cells mature, this plasticity decreases, which is why adult language learners experience certain difficulties in mastering, e.g. native-like accents. But at the same time, it seems as if phonology and prosodic features are the only (or main) subsystems of language that cause difficulties for grown up learners (Lenneberg, 1967). Nevertheless, as indicated by Hakuta (1999:11) “the evidence for a critical period for second language acquisition is scanty […]. There is no empirically definable end point; there is no qualitative difference between child and adult learners […]. The view of a biologically constrained and specialised language acquisition device that is turned off at the puberty is not correct.” Furthermore, Robertson (2002) pointed out that there are other factors, such as motivation, language aptitude, and intelligence, which can contribute to one’s high proficiency in a second language during later stages of life.

The age of acquisition is just one aspect that can be used to classify bilingual speakers, the mode of acquisition is yet another. In 1984, McLaughlin coined the terms *simultaneous bilingualism* and *successive bilingualism* that relate to both languages either being acquired at the same time or being learned at different ages. The former version of bilingualism generally refers to very young learners who are brought up, for example, in a one parent one language environment, whereas the latter usually pertains to older learners who receive formal language instruction and as a result of which learn the second language consecutively. In the past, simultaneous bilinguals were believed to have a compound (fully integrated) semantic system for two linguistic codes. On the other hand, the mental lexicon of successive bilinguals was seen as being organised in a coordinate (two semantic systems and two linguistic codes) or subordinate (the weaker language is mediated through the stronger language) way (Ervin and Osgood, 1954; Weinreich, 1953). However, nowadays, there is a tendency to assume that within the same bilingual, words may have various relationships with each other (subordinate, coordinate, and compound), especially if they were acquired at different times in different cultural contexts (Grosjean, 1998).

The classification of bilinguals can also be done according to the level of language proficiency. Romaine (1995) made a distinction between *semilinguals,* people who have insufficient knowledge of both of their languages; *balanced bilinguals,* those of roughly equal skills in both languages; and *dominant bilinguals*, those that have superior knowledge of one of the languages. Balanced bilinguals were the main focus of most research studies conducted after the 1960's. It was believed that investigations carried out with these groups would more likely display a positive relationship between cognitive and linguistic abilities (e.g. Hakuta and Diaz, 1985; Peal and Lambert, 1962). However, nowadays, there is a growing tendency among researchers to agree that hardly any bilingual person possesses balanced knowledge of both linguistic systems and that the majority present a preference for one of the languages. In line with this claim, Grosjean (1998) proposed that the term *dominant bilingualism* describes bilinguals most precisely as they are rarely equally fluent in all language skills in both linguistic systems. This is due to the fact that language history, language stability, or linguistic experiences of different languages are experienced asymmetrically by individuals. That is, these particular features, referred to as *complementarity principles*, greatly impact on the nature of individual linguistic abilities. Thus, in Grosjean's opinion, bilinguals are "those people who use two (or more) languages (or dialects) in their every day lives" (ibid., 1998:132). This definition denotes regular use and communicative competence (Francis,

1999) and it allows for a classification of a vast array of bilingual people, and that is why it was selected as the operational definition in this study.

2.2 Mental lexicon

The mental lexicon can metaphorically be understood as a dictionary or a database of all words stored in the mind of the language user (Dijkstra, 2005). It is stored in the long term declarative memory (Ullman, 2004) together with all of the encyclopaedic knowledge that we possess about the world. Each word contained in the lexicon can comprise up to eight different types of information, i.e. phonological, articulatory, orthographic, morphological, syntactic, semantic, idiomatic, and pragmatic (Schreuder, 1987 cited in Kroll and De Groot, 2005). However, when modelling the memory structure, there is a general tendency to focus on three main areas, i.e. lexical (orthographic and phonological), syntactic, and semantic, which are organized in a hierarchical way (Jackendoff, 1997). Hence, for each known word, we should be able to tell how it is spelled, pronounced, how it relates to other words in order to make phrases or sentences, and what the meaning of it is. This threefold division describes the structure of lexical entries in a monolingual dictionary. However, for a bilingual speaker the situation presents itself in a more complex way. Based on these three categories, three plausible designs describing a bilingual lexicon can be advanced. One possibility is that for each new word learnt in the second language (L2), an additional and separate piece of information is created on each of the levels, i.e. lexical, syntactic and semantic. Alternatively, each newly acquired word in L2 uses the already existing and available information in the first language (L1) to build upon or to add onto the shared representation. Finally, it is also possible that some of the information is shared e.g. semantic information, and some is separate e.g. lexical information (Finkbeiner et al., 2002). At present, the majority of models typically incorporate this final proposition into their structural representation. They agree on lexical information being separate for L1 and L2, but differ as to whether the conceptual store is presented as shared or distributed. In order to explore this notion further, several bilingual memory models will be examined below.

2.2.1 Models of the bilingual mental lexicon

It has to be noted that many of the models discussed next were developed based on the theoretical assumptions of their predecessors and there are a number of similarities that can be found between them. The majority of models' proponents agree that with each new word learned, a trace is left in memory either in a phonological and/or orthographic form, which is then associated with meaning. They also concur that there are two separate lexical stores, one for L1 and one for L2. They differ, however, in their propositions of how meanings of words are stored in the bilingual lexicon (shared versus separate conceptual store) and how a person can access meanings of L2 words (direct access from L2 versus access mediated through L1).

2.2.1.1 Weinreich's models

The first study to report a distinction between the ways in which translation equivalents[4] are stored in a bilingual memory was conducted by Weinreich (1953). He proposed three possible mental configurations: coordinate, compound, and subordinate. The Coordinate Model (Figure 1) is an example of a distinct meaning model and assumes no connections between the two language systems. In such a framework, a bilingual would have two separate lexical forms and two conceptual representations, e.g. for the Chinese word *gǒu* (狗) and the English word 'dog'.

[4] *Translation equivalents* are words in different languages which refer to the same meaning or the same concept (Francis, 2005:252).

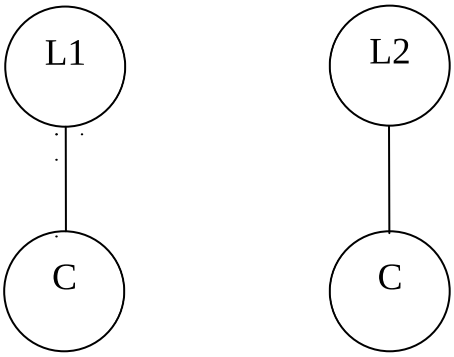

Figure 1. The Coordinate Model (adapted from Heredia and Brown in Bhatia, 2004), L1 stands for first language, L2 for second language, C stands for concepts.

The Compound (Figure 2, left) and Subordinate Models (Figure 2, right) are both examples of common meaning forms. The former assumes that there is direct access from both languages' lexical stores to one common conceptual store, whereas the latter purports that the meaning of L2 words can only be accessed through L1 mediation, i.e. through translation equivalents in L1. According to the first model, the meaning of the words *gǒu* (狗) and 'dog' can be accessed directly, whereas the subordinate framework suggests that the meaning of the Chinese word *gǒu* (狗) is accessed through its translation equivalent in English, i.e. the word 'dog'.

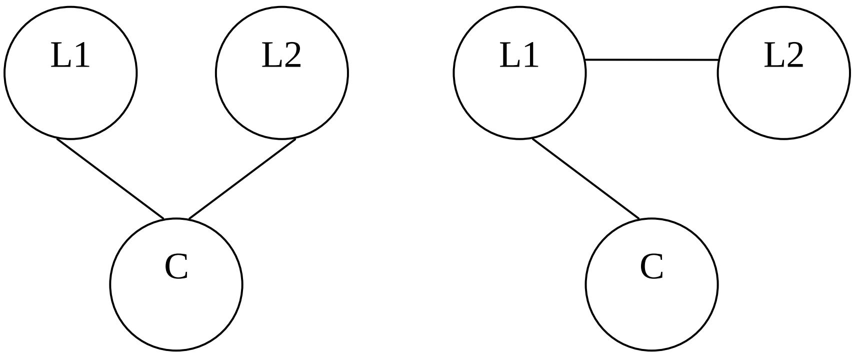

Figure 2. The Compound and Subordinate Models (adapted from Heredia and Brown in Bhatia, 2004), L1 stands for first language, L2 for second language, C stands for concepts.

2.2.1.2 Word Association and Concept Mediation Models

The subordinate and compound structures were later used by Potter and colleagues (1984) in the development of the Word Association and the Concept Mediation frameworks. For both of these models, the existence of a single conceptual store and two lexical stores, one for L1 and one for L2 is assumed. They also accept that there is an image store where word representations are stored[5]. They differ, however, in their proposition of how meanings of L2 words are accessed. Under the Word Association Model (Figure 3, left) it is hypothesised that speakers can only access the meanings of L2 words through L1 translation equivalents, whereas with the Concept Mediation Model (Figure 3, right) it is proposed that L1 as well as L2 word meanings are accessed directly.

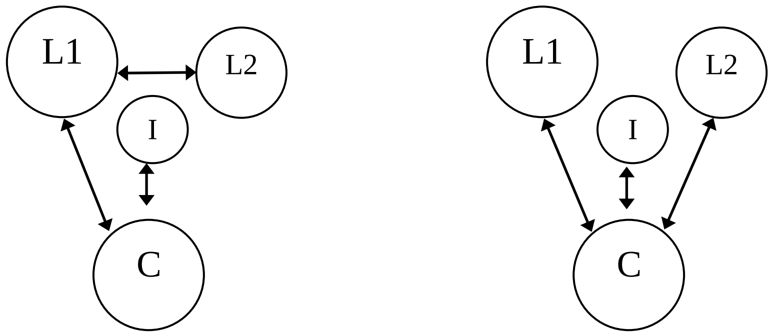

Figure 3. The Word Association Model and the Concept Mediation Model (adapted from Potter et al., 1984), L1 stands for first language, L2 for second language, C stands for concepts, I stands for images.

Potter and colleagues (1984) compared the performance of fluent Chinese-English participants and less proficient English-French bilinguals on an L2 picture naming task and an L1 to L2 translation production task. They assumed that according to the Word Association Model picture naming should take longer than translation, whereas according to the Concept Mediation Model there should be no difference between the two tasks (the assumed processing sequence leading to an L2 word production is shown in Table 1).

[5] Potter et al. (1984) made a distinction between the conceptual store and the image store based on a difference in naming time for words and pictures. Furthermore, Potter and Faulconer (1975) showed that words can be read out loud about 200ms to 300ms quicker than pictures of the same objects can be named.

Word Association Model		Concept Mediation Model	
picture naming in L2	**translation from L1 to L2**	**picture naming in L2**	**translation from L1 to L2**
1. recognize image	1. recognize L1 word	1. recognize image	1. recognize L1 word
2. retrieve concept	_	2. retrieve concept	2. retrieve concept
3. retrieve L1 word	_	_	_
4. retrieve L2 word	2. retrieve L2 word	3. retrieve L2 word	3. retrieve L2 word
5. say L2 word	3. say L2 word	4. say L2 word	4. say L2 word

Table 1. An outline of the processing sequence leading to production according to the Word Association Model and the Concept Mediation Model (adapted from Potter et al., 1984).

The comparison showed no difference between the reaction times across both types of tasks for the two groups of participants. Thus, based on the prediction that picture naming and translation involve similar component processes, i.e. conceptual access prior to retrieval of the L2 word (Kroll and Stewart, 1994; Kroll and Tokowicz, 2005), the Concept Mediation Model was adopted as resembling the bilingual lexical memory more accurately. However, the results presented by Potter and colleagues (1984) were counterintuitive, i.e. regardless of the proficiency of their participants (fluent Chinese-English and less fluent English-French bilinguals) the results were the same. It was demonstrated by a number of other studies (e.g. Chen and Leung, 1989; de Groot and Hoeks, 1995; Kroll and Curley, 1988) that bilinguals might rely on both representations, but at different stages of language development, i.e. on the word association in the early stage of language proficiency and on the concept mediation once a more fluent stage has been attained. For example, de Groot and Hoeks (1995) in a study with trilingual Dutch-English-French speakers, provided evidence for such a developmental shift. They manipulated the word concreteness in a translation production task and a translation recognition task from L1 (Dutch) to either L2 (English) or L3 (French). They showed that a concreteness effect was observable during the Dutch-English (L1 to L2) translation but not during Dutch-French (L1 to L3) translation. In short, the Concept Mediation Model best accounted for the results for the L1 to L2 translation, whereas the Word

Association Model better explained the L1 to L3 translation results. Therefore, the results presented by Potter and colleagues (1984) should be treated with caution as it is likely that the selection of the less proficient participants[6] biased the findings.

2.2.1.3 Revised Hierarchical Model

To account for the conflicting findings and specifically for the developmental shift (from word association to concept mediation), Kroll and Stewart (1994) proposed the Revised Hierarchical Model (RHM) (Figure 4). The model incorporated aspects of both the Word Association Model and the Concept Mediation Model and systematised previous findings (Kroll and Stewart, 1994). The RHM framework assumes the existence of one common conceptual store and two separate lexical stores, one for each language (with the L2 being smaller than that of L1 as it is assumed to contain less information). Compared with the previous models, the RHM is more elaborate, in terms of the number and strengths of bidirectional connections between the stores. The model assumes that the link between L2 and L1 is stronger than the one in the opposite direction. Also, it purports that the link between L1 and the shared concepts is stronger than the one between L2 and these. The different strength of connections reflects the fact that bilinguals often acquire words in L1 first (especially successive bilinguals) and they rely a lot on translation from L2 to L1 especially during early stages of language learning.

[6] The participants were described by Potter et al. (1984) as less proficient but as a matter of fact they were a group of highly motivated students who were preparing themselves to take part in a study abroad programme in France (Kroll and Tokowicz, 2005).

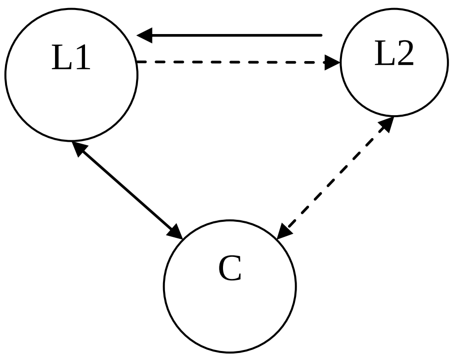

Figure 4. The Revised Hierarchical Model (adapted from Kroll and Stewart, 1994), L1 stands for first language, L2 for second language, and C stands for concepts.

Support for the RHM was initially obtained from a study with fluent Dutch-English bilinguals. They were asked to translate (from L1 to L2 and from L2 to L1) words presented in a semantically categorized list (e.g. all fruits or all animals) and semantically mixed list (i.e. words from different categories: fruits, animals, etc., presented together). The analysis showed that L1 to L2 translation was slower and less accurate than translation from L2 to L1. Also, translation from L1 to L2 was influenced by the semantic category, whereas L2 to L1 translation remained unaffected. This variation, known as translation asymmetry, was understood to show that "translation from the first language to the second is conceptually mediated, whereas translation from second language to the first language is lexically mediated" and does not require the retrieval of concepts (ibid., 1994:168). A number of studies (e.g. Kroll et al., 2002; Sunderman and Kroll, 2006; Talamas et al., 1999) have since further confirmed the propositions outlined by the RHM. It was also further suggested that bilinguals who are less proficient use the word association route more often than bilinguals of greater language proficiency (e.g. Talamas et al., 1999). This might be due to the fact that in the early stages of language learning bilinguals rely a lot on translation of L2 words to L1 words; hence, they strengthen the L2 to L1 connection. On the other hand, more proficient speakers employ the concept mediation route more frequently, i.e. they access meaning directly from L2. To exemplify this, Talamas et al. (1999) required two groups of bilinguals of varying proficiency in English and Spanish to recognize translation equivalents. The findings were consistent with the proposed developmental shift, in that the less fluent participants relied more on the word association path, whereas the more proficient ones depended on the concept mediation. This developmental aspect captured by the RHM is seen by many researchers (e.g. Pavlenko, 1999) as the most significant contribution of this framework to the understanding of the bilingual lexical memory.

However, contradictory findings have also been reported (e.g. Altarriba and Mathis, 1997; de Groot and Poot, 1997), and the model has been subject to a lot of critique. For instance, Brysbaert and Duyck (2010:359) said that the "basic tenets of the model have been called into question" due to the fact that, inter alia, there is little evidence for separate lexicons and language selective access[7]. In addition, the strength of connections between L2 words and meanings seems to be greater than that proposed by the model. Brysbaert and Duyck (2010) presented evidence from several different tasks, e.g. a translation task (de Groot et al., 1994), a Stroop task (La Heij et al., 1996), and a semantic Simon task[8] (Duyck and de Houwer, 2008), supporting the relevance of concept mediation in L2 comprehension and in L2 to L1 translation. Furthermore, Brysbaert and Duyck (2010) made a suggestion that it is probably time to abandon the RHM and focus on computational models, e.g. the Bilingual Interactive Activation (BIA) Model or the BIA+ Model[9] (Dijkstra and Van Heuven, 2002). However, Kroll and associates (2010) refuted the critique by stating that the original RHM never assumed

[7] Language selective access refers to the activation of only the language that is being used at a given moment of time as opposed to non-selective access that refers to a simultaneous/parallel activation of both languages.

[8] A semantic Simon task is an example of a case-judgment task. Duyck and de Houwer (2008) asked their participants to respond to words written either in upper or lower case but to ignore the meaning of the words.

[9] BIA and BIA+ are connectionist models of the bilingual visual word recognition. The BAI+ model is an extension of the BIA model; it contains not only orthographic representations and language nodes, but also phonological and semantic representations. Both models are language-nonselective access ones that distinguish between hierarchically organized levels of different linguistic information (Dijkstra, 2005:190).

lexical non-selectivity as little evidence was available supporting this notion at the time when the model was proposed. Furthermore, Kroll and colleagues (2010) put forth the point that parallel (non-selective) access does not necessarily suggest an integrated lexicon (van Heuven et al., 1998). Additionally, Kroll and colleagues (2010) admitted that the assumption of the RHM about understanding L2 words via L1 translation equivalents was not correct. Nonetheless, evidence, as early as 1995, demonstrated that less proficient bilinguals can also employ the concept mediation route, e.g. in a categorization task (Dufour and Kroll, 1995). Thus, Kroll and associates (2010:379) concluded that “Brysbaert and Duyck have lost sight of the larger picture” and that even though the RHM is more than fifteen years old, it is still potent enough to account for new findings presented in the field.

The RHM is very robust and still popular amongst researchers in the field of psycholinguistics. However, there is one another aspect of this model that makes it difficult to accept its original ‘architecture’. It is probably the only remaining psycholinguistic model that presents the conceptual level of information as fully overlapping. A majority of other recent models, such as: the Distributed Feature Model (de Groot et al., 1990’s), the Sense Model (Finkbeiner et al., 2004), the Shared Asymmetrical Model (Dong et al., 2005), and the Modified Hierarchical Model (Pavlenko, 2009) propose a certain degree of distribution at this level of representation. If we follow the instantiation of a fully integrated conceptual level of representation, it is possible to deny the existence of language and culture specific concepts. Indeed, this claim about a fully shared conceptual store is actually the major critique of the model offered by Pavlenko (2009), who contended that “the unified and stable nature of the conceptual store assumed in the RHM does not accommodate the cases of partial equivalence[10] and complete non-equivalence, and does not allow us to differentiate between target- and non-target-like performance in mapping words to referents" (ibid, 2009:143). This point of view has been further reiterated by other researchers. Francis (2005:260), after conducting a review of the literature on semantic processing, concluded that "the evidence may not be strong enough to confirm completely shared representations at the semantic level". Gathercole and Moawad (2010:386) gathered evidence from several studies to demonstrate that "the semantic organization of the words in the bilingual's two languages cannot consist of simple isomorphism between the two systems". They further showed that about 25% (Tokowicz et al., 2002) to 69% (Prior et al., 2007) of words are not isomorphic. Also, de Groot (1992) and de Groot and Nas (1991) suggested that it is likely that concrete and cognate words share a semantic system, but abstract or noncognate words do not necessarily share a common one. Hence, the unified nature of the conceptual store as represented by the RHM is certainly questionable.

The improbability of this claim becomes even more apparent when we look at examples drawn from different languages. For instance, there are many concepts that can only be found, say, in L1 which have no translation equivalents in L2. In English, the word *nut*, which subsumes cashews, peanuts, walnuts etc., does not have a translation equivalent in the Spanish language. Furthermore, the Spanish word *estrenar*, which refers to doing or using something for the first time, does not have an equivalent term in English (Gathercole and Moawad, 2010). Even in very closely related languages, like Dutch and English, words that share multiple polysemous applications can be seen as permissible or not. An example of such a word would be *break* or *breken* in Dutch. Usage of *break* in English sentences translated from Dutch, such as *He broke his leg* and *She broke his*

[10] Pavlenko (2009) differentiated between *conceptual equivalence, partial (non)equivalence,* and *conceptual non-equivalence.*

heart, are seen by Dutch participants as acceptable, but not in sentences such as: *His fall was broken by a tree* and *A game would break up in the afternoon a bit* (Kellerman, 1978, 1979, 1983 in Gathercole and Moawad, 2010).

Lexical items that do not have translation equivalents can be found in other languages too. For example, Wierzbicka (1992) showed that Polish speakers have different names/labels for a telephone table (stolik)[11], a coffee table (ława) and a dining table (stół), whereas English speakers use just one name (table) to describe the three, but distinguish them with the adjectives (telephone, coffee, dining). Also, the English words *fingers* and *toes* have one category in Spanish *dedos* and the Arabic term *maktab* refers to *desk* and *office* in English (Gathercole and Moawad, 2010). These are just few examples demonstrating that concepts are not universal across different languages and cultures (Ameel et al., 2009) and that "translation equivalents are not always conceptual equivalents" (Pavlenko, 2009:133).

Moreover, even if concepts are common between L1 and L2, they are often culture-specific or have some salient extensions (denotations or connotations) that are only present in one of the languages[12]. An example of this was given by Dong and associates (2005), who used the concept of the colour *red* to exemplify that translation equivalents apart from sharing common elements also retain language specific elements. More specifically, they explained that a common element between Chinese and English would be the concept of the 'colour' *red* and *hóngsè* (红色), whereas the concept of 'danger', 'alert', 'passion' would be more pronounced in the English word *red* than in the Chinese

[11] The Polish word *stolik* is a diminutive form of the word *stół* and when directly translated into English it would mean a little table.

[12] Pavlenko (2009:133) stressed the fact that "cross-linguistic studies in cognitive psychology, cognitive linguistics, and linguistic anthropology show that speakers of different languages rely on linguistic categories that may differ in structure, boundaries, or prototypicality of certain category members".

word *hóngsè* (红色) and the concept of ‘bride’, ‘good fortune’, ‘prosperity’ would be more salient in Chinese *hóngsè* (红色) than in English *red* (ibid, 2005:233). Furthermore, Lehrer (2009) gave examples of verbs that share prototypical meaning but differ in their extensions across different cultures, even very closely related cultures. For instance, the verb ‘run’ has the same core meaning in American and British English, but when the same verb is extended to refer to a politician seeking election to an office, the British no longer say ‘run for office’ but ‘stand for office’.

Finally, a great number of concepts, even if they are shared between L1 and L2, retain referents that are culture specific. Jared and colleagues (2013) provided an example of this. These researchers investigated picture naming in Mandarin-English, specifically Canadian, bilinguals using images that were either culturally-biased or unbiased. Their findings demonstrated that culturally-biased pictures are named quicker in a congruent language and this, in turn, may indicate that some concepts are more strongly connected to say L1 rather than L2. However, for the purpose of this discussion, the stimuli that were used by Jared and colleagues (2013) seem to be more interesting than the finding itself. As it can be seen in Figure 5 below, concrete common items, such as a: mailbox, cage, cabbage, or a mask, differ in shape and size between Chinese and Canadian cultures.

Figure 5. Examples of culturally-specific stimuli used by Jared et al. (2013:390).

In view of the above presented examples, it is difficult to claim that the conceptual level of information is fully overlapping, as depicted by the RHM (Kroll and Stewart, 1994). It could be hypothesised therefore that there are two conceptual stores, one for L1 and one for L2 that are highly integrated and overlap to a great degree. The overlapping area would represent the extent to which the elements are shared between the two languages, whereas the separate C1 and C2 areas would represent language or culture specific concepts. Following this line of reasoning, a modification can be put forward for the RHM as depicted in Figures 6A and 6B below.

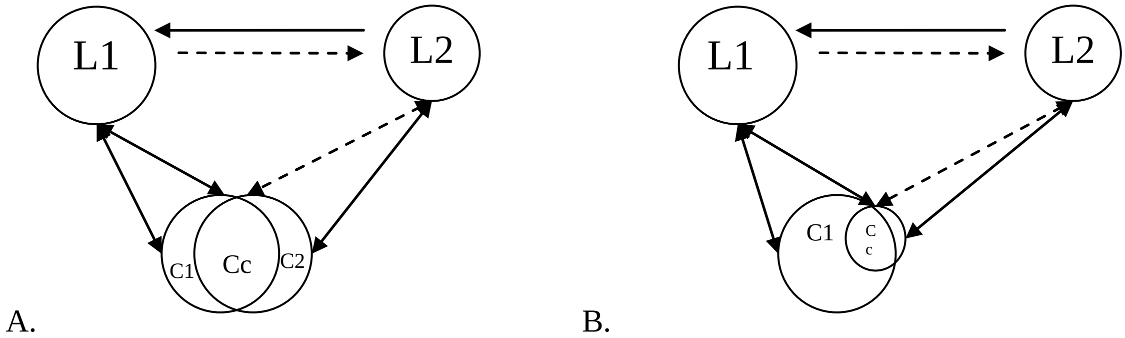

Figure 6. The Revised Hierarchical Model with modified conceptual store.

Figure 6A presents a hypothetical model describing a substantial conceptual overlap between two conceptual stores (which can be named as C1 and C2). The overlapping area in the middle could represent common concepts (Cc), whereas the edges of the circles to the left and to the right could stand for the language specific concepts. The additional arrows between L1 and concepts and L2 and concepts could indicate a direct access to the common area as well as a direct access to the language specific parts. The connection between L2 and common concepts would be considered weaker than the remaining ones, for instance, in a situation when L2 is still in the process of developing. This representation (Figure 6A) could account for several possible scenarios, e.g. (1) concrete or cognate words, (2) a conceptual overlap between closely related languages or (3) a well-established conceptual representation of a simultaneous bilingual. On the other hand, Figure 6B could be interpreted as depicting a slight overlap for abstract words, noncognate nouns or verbs and it could also present an overlap between languages that are relatively distant. Finally, it could also depict a situation when an L1 native speaker starts learning a second language and the C2 is relatively small, thus reflecting the developmental nature of the learning process. This model, in its two versions, is more flexible as compared to the original RHM, for it can account for representations of different word classes and comparisons of different languages. It also encapsulates the dynamic nature of language development, by assuming different sizes of the conceptual stores, different degrees of semantic overlap, and different strengths of the connections between L1, L2 and concepts.

To investigate the conceptual level of information, i.e. shared vs. distributed, this researcher made a decision to test the RHM with reference to Chinese-English bilinguals. The majority of previous studies which addressed this framework focused on groups of Indo-European bilingual speakers. However, the specific differences that can be found between two highly distinct languages, like Chinese and English, may have particular impact on the 'architecture' of the model. Furthermore, because many previous studies concentrated more on the holistic organisation of the model and the language processing aspect of it, little is known about the representation of each of the hierarchically organized levels of information. That is why, for this study specifically the representation of the conceptual store was investigated, whereby the notion of shared versus separate representation was under examination. Also, the strength of connections between the two lexical stores and the conceptual store was researched. Evidence was gathered to examine if the L1 to C connection is stronger than L2 to C (the representational account (Jiang, 1999)). Nevertheless, before the discussion regarding the conceptual store is initiated it is worth considering some of the models that propose distributed conceptual representations. Here, two models are discussed, the Shared (distributed) Asymmetrical Model (Dong et al., 2005) and the Modified Hierarchical Model (Pavlenko, 2009).

2.2.1.4 Models that propose distributed conceptual representation

The Shared (distributed) Asymmetrical Model (SAM) (Dong et al., 2005), presented in Figure 7, encapsulates the notion of common elements and language/culture specific elements. The model consists of one large store of common elements and two separate relatively smaller stores of L1 specific and L2 specific elements. The different sizes of the stores are suggested as these researchers assume that “for the great majority of translation equivalents, the magnitude of their common conceptual elements is much greater than their language or cultural specific elements” (ibid, 2005: 233). Furthermore, the connections between the conceptual and lexical stores are complex and vary in strength.

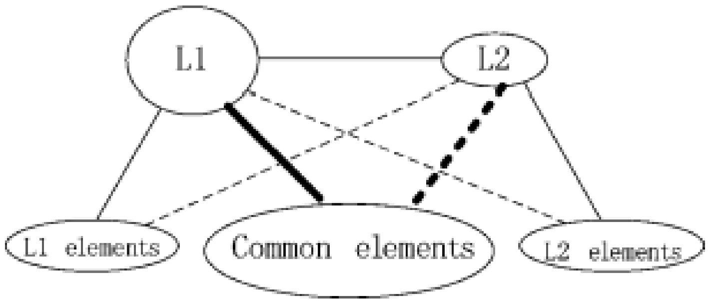

Figure 7. The Shared (distributed) Asymmetrical Model (Dong et al., 2005).

The SAM presents a dynamic view, which accounts for common as well as L1 and L2 specific elements. It also illustrates the process of *conceptual convergence*, i.e. the emergence of an intermediate level of representation due to the interaction between L1 and L2. Nonetheless, Pavlenko (2009:146) criticised this model for lacking clarity when it comes to the nature and structure of conceptual representations. Also, Dong et al.’s (2005) work suggests that there are three separate stores at the conceptual level that are independent of each other. Moreover, no direct connections between the conceptual stores are assumed. This scenario is not likely in the light of data obtained from psycholinguistic studies (e.g. priming studies) and also neurolinguistic investigations. For instance, Indefrey (2006) conducted a comprehensive meta-analysis of 30 brain imaging studies on first and second language processing and concluded that there are no distinct cortical areas for L1 and L2, the only observable difference being in a slightly greater activation of L2. Hence, it is implausible that the conceptual stores are separate from each other.

Pavlenko (2009) proposed yet another bilingual lexical memory model, the Modified Hierarchical Model (MHM) (Figure 8). It retains the strengths of three other models: the RHM, the Distributed Feature Model (de Groot, 1990's) and the Shared Asymmetrical Model (Dong et al., 2005). However, it differs from the other models in three important ways: (1) the organization of the conceptual store, (2) the recognition of the phenomenon of *conceptual transfer*, and (3) the view of L2 learning that is embedded in the model.

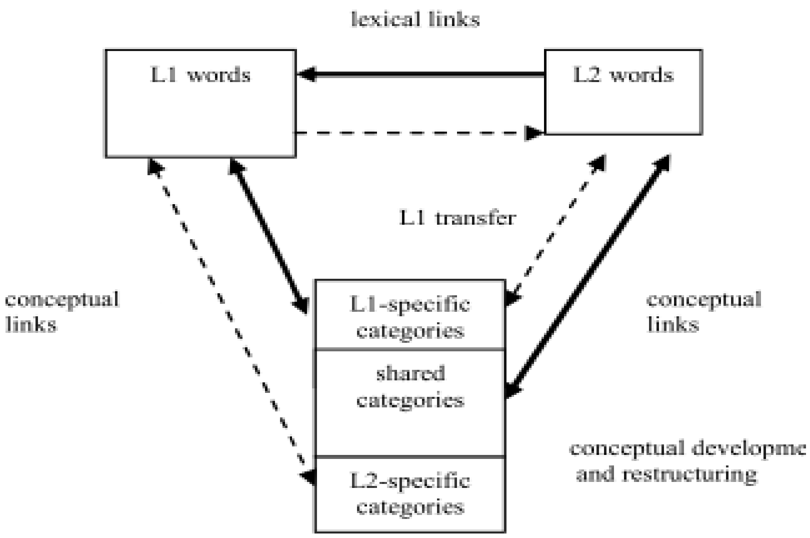

Figure 8. The Modified Hierarchical Model adapted from Pavlenko (2009).

Under the MHM, it is not proposed that there is a unified conceptual store, but rather that there is a distributed representation that can be fully or partially shared or is specific to L1 or L2. Also, it differentiates between semantic representation and conceptual representation and holds to two situations of conceptual transfer. That is, the use of L2 words in accordance with L1 linguistic categories will result in L1 conceptual transfer, and correspondingly L2 conceptual transfer will occur if the languages are reversed.

Finally, the model's proponent sees the main goal of L2 learning as a gradual process of conceptual restructuring that takes place in the implicit memory. From this, it can be seen that the model proposed by Pavlenko is very comprehensive, for it takes into account cross-linguistic differences in linguistic categories as well as it differentiates between semantic and conceptual levels of representation and between implicit and explicit knowledge. However, it is relatively new and up to now has not been empirically verified. It certainly presents a promising theoretical framework, but one that is difficult to test. Regarding this, first of all, it is a rather laborious task to find concepts in two chosen languages that are partially-equivalent, and/or non-equivalent and design e.g. a priming task. Secondly, Pavlenko made a very clear distinction between conceptual representation and semantic representation and the model is based on so called *lexicalised concepts*[13]. Concepts and semantics are two notions that are very difficult to discern empirically and up to now this has not been mastered. This brings us to one another important point, i.e. before any exploration of the semantic representation is undertaken, it is crucial to first of all understand what type of information is stored at this level of representation and how it can be measured. These two elements will be discussed in the next section of this chapter.

2.3 Conceptual store

There is no consensus among researchers regarding the type of information stored at the conceptual level of representation. In general, it is possible to distinguish between two approaches: the old approach, also known as the one-level view and the new approach, often referred to as the two-level view. The representatives of the one-level view to concepts (e.g. de Groot, 2000; Roelofs, 2000) postulate that word meanings and concepts are stored together. They argue that it would be a laborious or maybe even an impossible

[13] Lexicalized concepts are linked to words, e.g. *bird* or *chair* (Jarvis and Pavlenko, 2008).

process to differentiate between the two levels of representation and “pinpoint the essence of semantic representation” (de Groot, 2000:8). On the other hand, the instigators of the two-level view (e.g. Jarvis, 2000; Paradis, 1997; Pavlenko, 1999) see concepts and word meanings as related but separate phenomena. That is, they postulate there is a clear distinction between semantic and conceptual representations, because according to these researchers the representations contain different types of information, which is not clearly distinguished in the models of bilingual lexical memory. Since the debate regarding this matter is ongoing, it is next considered in more detail.

2.3.1 Word meanings versus concepts

Pavlenko (2000a:3), as the instigator of the new approach to concepts, stated that “conceptual representations should be treated as related but not equivalent to word meanings.” She based this on evidence from global aphasia[14] patients, who experience language loss, but still retain conceptual representations (e.g. Paradis, 1997). That is, aphasic patients can distinguish between a cat and a dog, but are unable to produce or comprehend the words *cat* and *dog* (Roelofs, 2000). Pavlenko developed her argument further by stating that *semantic representations* can be understood in terms of largely implicit knowledge as the mapping between words and concepts[15] and connections between words[16]. *Conceptual representations* can also be comprehended in terms of implicit knowledge but of a slightly different nature. They involve knowledge of (1) properties and/or scripts associated with a particular category; (2) category prototypes and peripheral members; (3) the internal structure of a category and links with other categories (Jarvis and Pavlenko, 2008:118). This knowledge can comprise visual, auditory, conceptual and/or kinaesthetic information. Pavlenko (2000) emphasised the

[14] Global aphasia is a combination of severe Broca’s and Wernicke’s aphasia, characterised by almost total inability to produce and comprehend language.
[15] The mapping between words and concepts accounts for polysemy.
[16] Connections between words account for collocations, word associations, synonyms and/or antonyms.

fact that psycholinguists deal only with a small proportion of all concepts, namely those acquired and accessed via language and since the majority of the memory models focus on language-based concepts, they can be seen as reductive in nature. Pavlenko suggested that the bilingual memory models should be able to account for: *lexicalized, grammaticized*[17], and *conventionalized*[18] concepts.

Similarly to Pavlenko, Paradis (1997) argued that we cannot assign a one-to-one correspondence between concepts and word meanings. He distinguished between a *semantic component* and a *conceptual component.* According to this author, the first of the components is stored in the *explicit/declarative*[19] memory and refers to the way words relate to other words, e.g. in conventionalized and idiomatic expressions[20]. The *conceptual component,* on the other hand, is encoded in the *implicit*/*procedural*[21] memory. It is a non-linguistic multi-modal component and is based on experiential world knowledge. Paradis further argued that concepts are abstractions that are dynamic in nature and fractionable, i.e. at any particular time only a portion of a concept is activated. Moreover, the constraints of a given situation as well as individual experience (including cultural background) settle which part of a concept is appropriate in a given context (ibid). Pavlenko and Paradis' accounts are very similar, for they both emphasise the fact that semantic and conceptual representations should not be confused. This view has been adopted by many researchers. For instance, Daller and associates (2011) in their study on the transfer of conceptualisation patterns in bilingual Turkish-German speakers made a

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[17] Grammaticized concepts are linked to morphosyntatic categories, e.g. number, gender, or aspect (Slobin, 2001).

[18] Conventionalized concepts refer to the domain of pragmatics and ways of performing speech acts, e.g. requests or apologies (Pavlenko, 1999).

[19] Explicit memory is a memory system, also referred to as declarative memory and pertains to memories, information, experiences which can be consciously recalled. The explicit memory comprises semantic and episodic memory.

[20] Idiomatic expressions are phrases or sayings that are often used in non-standard speech by the native speakers of a language, the meaning of which cannot be easily understood from the translation of individual words comprising the phrase.

[21] Implicit memory is a memory system, also referred to as procedural memory that refers to memories, information, experiences which cannot be consciously recalled.

very clear distinction between semantic and conceptual structure, focusing on the latter. Nonetheless, the majority, if not all, of the models of bilingual memory representation, proposed so far in the field of psycholinguistics, do not make such a clear cut difference between concepts and word meanings. The only two models that are an exception to the rule are the Word Association Model and the Concept Mediation Model (Potter et al., 1984). That is, they assume a separate image and conceptual store; however, the theoretical predictions of this framework were not further developed by other researchers in the field. Hence, the majority of memory models available today hold to an integrated semantic/conceptual level of information.

Nevertheless, the one level view was defended by e.g. de Groot (2000) who articulated that the memory representation models actually never addressed the content of conceptual representations. That is, the models did not differentiate between word meanings and concepts because the data on which they were based did not substantiate the existence of both types of representations. She stipulated that there must be a clear distinction made between lexical forms (orthography and phonology) and semantic/conceptual representations. However, when it comes to the latter notion, according to her, first, it is, necessary to provide an unambiguous definition of both levels of representation in order to be sure that a particular memory store is affected in an aphasic person (ibid). Furthermore, Roelofs (2000) argued that it is actually not necessary to separate word meanings and concepts, also claiming that the one-level approach is simpler and it should be preferred over the two-level view. To support his standpoint and to explain the data obtained from global aphasic patients, he referred to the one-level model, the WEAVER++ model[22] of word production (Levelt et al., 1999; Roelofs, 1992, 1993). He contended that the impairment in aphasic patients most likely

[22] WEAVER++ is a model of a monolingual word production in which a distinction is made between conceptual preparation, lemma retrieval, and word-form encoding (Roelofs, 2000:25).

occurs between the concept-to-lemma[23] connections and hence language production and comprehension problems are observable but not concept retrieval problems. Roelofs (2000:26) noted that "a [brain damaged] patient should have difficulty naming a dog, but the capacity to conceptually identify the dog and to infer that it can bark should be spared."

To sum up, word meanings and concepts are clearly bound together, but it is difficult to discern the two notions in an empirical way. Furthermore, the majority of the bilingual memory models do not account for a distinction at this level of representation. That is why, the one-level view, the old view on concepts is preferred in this study. *Word meanings* are understood as the mappings of verbal labels to their concepts (Francis, 2000). Moreover, the terms *conceptual level, conceptual store*, and *semantic level of representation* are taken as referring to an integrated semantic/conceptual system and are used interchangeably (Francis, 1999, 2005). Furthermore, the focus is on those concepts/meanings that can be acquired and accessed through language (Pavlenko, 2000) since this is a psycholinguistic investigation. Additionally, concepts/meanings are understood to be linked to real life referents in the form of objects, events, properties, and also abstract notions (Paradis, 2000). Having defined the type of information that is stored at the semantic level, the discussion now focuses on the paradigms commonly employed to measure semantic representations.

2.3.2 How to measure concepts

A number of methods have been used in psycholinguistics to examine the semantic representation and processing in bilinguals. The most often employed research methods are: the Stroop task, translation production, translation recognition, picture naming, and

[23] "Lemma […] is a representation of the syntactic properties of a word, crucial for its use in sentences" (Roelofs, 2000:25).

priming. All of these paradigms are designed to measure reaction times (RT), error rates (ER), and/or omission rates (OR), and they aim to show either facilitation (an increase of the ease or intensity of response or a decrease in response time) or inhibition (a decrease of the ease or intensity of response or an increase in response time). Each of these paradigms are considered separately below, except for the priming paradigm which is discussed in greater detail further on in this chapter (subsection 2.5.1). Special attention is paid to those studies that were conducted with Chinese-English bilingual participants.

2.3.2.1 The Stroop interference effect

In a typical monolingual Stroop task (Stroop, 1935) participants are presented with a colour of ink and are asked to name it. The ink might be presented in a congruent condition (a word denoting a colour is presented in coloured ink and the colour of the ink matches the meaning of the word) or an incongruent condition (e.g. a word denoting the colour *blue* is written in yellow ink). With bilingual participants a cross-language condition is usually introduced, e.g. they are presented with a name of a colour in L1 (*red*) but are asked to name it in L2 (*hóngsè*, 红色) (an example of a single congruent and incongruent trial is given in Table 2).

	congruent condition	**incongruent condition**
presented stimuli		
expected response	red	green

Table 2. An example of a congruent and incongruent condition from a cross-language Stroop task

In this paradigm interference is usually observed in the incongruent condition, which reflects on the fact that participants cannot suppress the automaticity of language processing, i.e. they automatically read and respond to written words rather than the colour of the ink. Chen and Tsoi (1990:127) noted that "the amount of interference [in a Stroop task] reflects the extent that two cognitive processes […] share similar processing resources." In the case of a bilingual person, greater interference between L1 and L2 processing can be interpreted as a certain degree of overlap between the two languages.

The Stroop task was very popular in the late 1970's and early 1980's, when there were numerous studies that were conducted with Chinese-English bilinguals (e.g. Chen and Ho, 1986; Fang et al., 1981; Smith and Kirsner, 1982; Tsao et al., 1979; Tsao et al., 1981). In more recent years there have also been a few studies that employed the Stroop task, e.g. Chen and Tsoi (1990) and Lee and Chen (2000). These studies employed this type of paradigm to measure hemispheric differences in the processing of Chinese and English colour words, and colour information (e.g. Tsao et al., 1979; Tsao et al., 1981). The same paradigm was used by other researchers to measure the possible impact of orthography on word processing (e.g. Chen and Tsoi, 1990; Fang et al., 1989; Lee and Chan, 2000; Smith and Kirsner, 1982). Even though the above outlined studies did not measure the semantic level of information directly, they did demonstrate the interference effect in a cross-language condition. Since the between language interference effect was comparable to the within language interference effect, it can be interpreted as resulting from a shared semantic system. Additionally, in view of the fact that the bilingual participants were not able to "ignore the meanings of words from the nontarget language" (Francis, 1999:210), it is possible to state that the processing of both languages is automatic (Altarriba and Basnight-Brown, 2009).

2.3.2.2 Translation production and translation recognition

Word translation, from L1 to L2 and from L2 to L1, is probably the most commonly employed paradigm for the investigation of the bilingual lexical memory (Salamoura and Williams, 1999). In this type of task participants are asked to produce a translation equivalent, e.g. in L2 if the stimulus was presented in L1. Often participants, who are less fluent in L2, are asked to perform a variant of the translation task, the translation recognition task (e.g. de Groot and Hoeks, 1995) (an example of both tasks is given in Table 3). During a recognition task participants normally see two words presented simultaneously or in succession on a computer screen and are asked to state whether a pair of words represents a translation of each other or not.

translation	
stimuli	1. 车轮 *(chēlún)*
	2. 肥皂 *(féizào)*
	3. 仓鼠 *(cāngshǔ)*
expected answer	1. wheel
	2. soap
	3. hamster
translation recognition	
stimuli	1. 车轮 *(chēlún)* - wheel
	2. 肥皂 *(féizào)* - table
	3. 仓鼠 *(cāngshǔ)* - cat
expected answer	1. yes
	2. no
	3. no

Table 3. An example of stimuli used in a translation and translation recognition task.

The translation paradigms were employed by de Groot and associates (e.g. de Groot and Comijs, 1995; de Groot et al., 1994; de Groot and Nas, 1991; de Groot and Poot, 1997). They used the tasks to investigate the translation asymmetry effect (subsection 2.2.1.3) and the way in which different classes of words are translated. The researchers found that elements such as imageability[24], concreteness, familiarity, cognate status, context availability[25], and definition accuracy affect translation latencies. In general, concrete words, which were familiar to the participants, had referents that were easy to imagine and were easy to use in context produced shorter reaction times (RT) when being translated. Furthermore, the researchers concluded that "conceptual representation in bilingual memory depends on word-type and grammatical class" (van Hell and de Groot,

[24] Imageability describes the easiness with which one can imagine a referent of a word.
[25] Context availability refers to the easiness with which one can produce a context for a word to be used in.

1998b:193). The researchers explained that concrete words, cognate translation pairs and noun translation equivalents, share semantic representations more often across two languages and to a greater degree, whereas abstract words, non-cognates and verb translations have lesser overlap of conceptual features. Tokowicz and Kroll (2007) also pointed out that the number of meanings that translation equivalents share affects both translation accuracy and translation latencies. The researchers employed a translation task to examine the concreteness effect and the impact of the number of meanings on the speed of language processing. Based on the data obtained from an English-Spanish sample, they showed that the concreteness of words alone does not influence the translation latencies. However, once words were matched on the number of meanings and concreteness, an advantage was shown, but, surprisingly, only for abstract words. Because the findings were the reverse to those formerly reported, it was concluded that previous concreteness effect findings might have resulted from a comparison of words with a different number of meanings. Tokowicz and Kroll's (2007) study is among a few that considered the impact of the number of translation equivalents on the speed of language processing[26]. Since little research has been carried out so far on the processing and representation of concrete and abstract words with multiple meanings, this issue is considered to be "a promising avenue for future research" (ibid., 2007:753).

2.3.2.3 Picture naming

Picture naming is yet another RT based task frequently employed in bilingual memory studies. In this paradigm, participants are asked to name, as quickly and as accurately as possible, pictures that are shown in succession on a computer screen. Picture naming is very useful, as it is believed to "activate the appropriate semantic information, rather than just activating lexical links between the L1 and L2" (Altarriba and Basnight-Brown,

[26] An unpublished paper by Schonpflug (1997), cited in Tokowicz and Kroll (2007), is the only other paper that discussed the influence of the number of translations on translation production.

2009:86). However, it is often not used as a main measure, but rather as a point of reference for other tasks. That is, acting as a baseline for a comparison, it provides information about processing rather than representation of semantic information. For example, picture naming was used alongside a translation task by Kroll and Curley (1988) and Chen and Leung (1989), who tested participants of different levels of language proficiency (a method similar to the one used by Potter et al., 1984). By comparing the RT from L2 picture naming and translation from L1 to L2, the authors found that the level of language proficiency determines the use of a particular processing path. It was reported that less proficient L2 learners rely more on word association, but as the language proficiency level increases, the processing preference shifts to concept mediation. Furthermore, Cheung and Chen (1998) also investigated the translation asymmetry effect and confirmed that not only the participants' level of proficiency but also elements such as familiarity of tested items may have an impact on the processing routes. In their study, proficient Chinese-English bilinguals were tested on picture naming, word translation, delayed production [27] (Balota and Chumbley, 1985) and category matching [28]. The first two tasks were used to measure the extent of communication between two lexicons (L1 and L2) and the conceptual store, whereas the two latter tasks gave information about response production and concept retrieval. Based on the analysis of RT, it was demonstrated that backward translation was faster than forward; L2 picture naming took the same amount of time as forward translation; L1 picture naming was faster than backward translation; and Chinese items were matched more quickly to categories than English ones. Nonetheless, when the items' familiarity rating was taken into account the difference between translation latencies (backward and

[27] In a delayed production task participants are asked to name pictures or words, but are not requested to respond as quickly as possible and instead are asked to delay naming until e.g. a pair of parentheses appears around the stimuli. Such procedure is used "to ensure a relatively pure measure of mere response production time for processing" (Cheung and Chen, 1998:1009).

[28] In a category matching task participants are required to make a decision as quickly as possible about whether presented stimuli belong to a superordinate category.

forward) disappeared, which might suggest that familiar items, regardless of the language, are more closely bound with the conceptual memory. Hence, “the translation of familiar L2 items would, therefore, involve more conceptual processing than that of unfamiliar L2 items” (ibid, 1998:1011). Based on the evidence provided above, picture naming can be seen as a useful point of reference for other tasks.

The psycholinguistic investigations of concepts with the use of a Stroop task, translation production, translation recognition and picture naming have provided a lot of valuable evidence about the processing and representation of concepts in a bilingual lexicon. However, to show a more comprehensive picture, it is also worth examining the neurolinguistic perspective on concepts as discussed next.

2.3.3 Neurolinguistic perspective on concepts

As in the field of psycholinguistics, the major research question that bilingual neuroimaging studies are trying to address is the one of shared versus separate cortical representations for L1 and L2. The general assumption is that, if bilinguals have one integrated conceptual store for L1 and L2 the same cortical areas should be activated while processing semantic information in each language. By contrast, if the conceptual store is separate for L1 and L2 it is likely that distinct cortical areas will be active (Francis, 2005). Furthermore, similarly to psycholinguistic data, there is empirical evidence supporting both overlapping brain regions (e.g. Chee et al., 1999; Chee et al., 2000; Illes et al., 1999; Xue et al., 2004) and different or partly different brain regions (e.g. Dehaene et al., 1997; Ding et al., 2003; Marian et al., 2007; Tan et al., 2003). For example, Chee and colleagues (1999) used fMRI[29] to scan the brains of highly proficient Mandarin-English bilinguals (15 early bilinguals who acquired L2 before the age of six

[29] Functional magnetic resonance imaging (fMRI) measures change in blood flow in the brain while participants are asked to perform a task, e.g. reading words aloud.

and 9 late bilinguals, who acquired L2 after the age of twelve), while they performed a cued word production task[30]. Based on the fact that Chinese is a logographic system[31] and English is an alphabetic one, the researchers made a prediction that there should be a visible difference between processing of the two languages, but surprisingly, no difference was observed. In both groups, brain activity was located in the left prefrontal cortex, along the inferior and middle frontal gyri. Similarly, Illes and colleagues (1999) asked Spanish-English participants to perform two tasks: a semantic decision task (in which participants had to make a decision as to whether words were abstract or concrete) and a nonsemantic decision task (in which participants had to make a decision as to whether words were printed in the lower or upper case), while at the same time scanning the participants' brains by fMRI. Again, the results revealed similar activation patterns for both languages (strong activation in the left inferior frontal gyrus and weaker activation in the right inferior frontal gyrus) (Figure 9). The results from this study can be interpreted as providing support for a common semantic system.

[30] In a cued word recognition task participants are presented with only part of a word, e.g. one syllable and are asked to recognize the whole of it.
[31] A logographic system is a writing system in which visual symbols represent words.

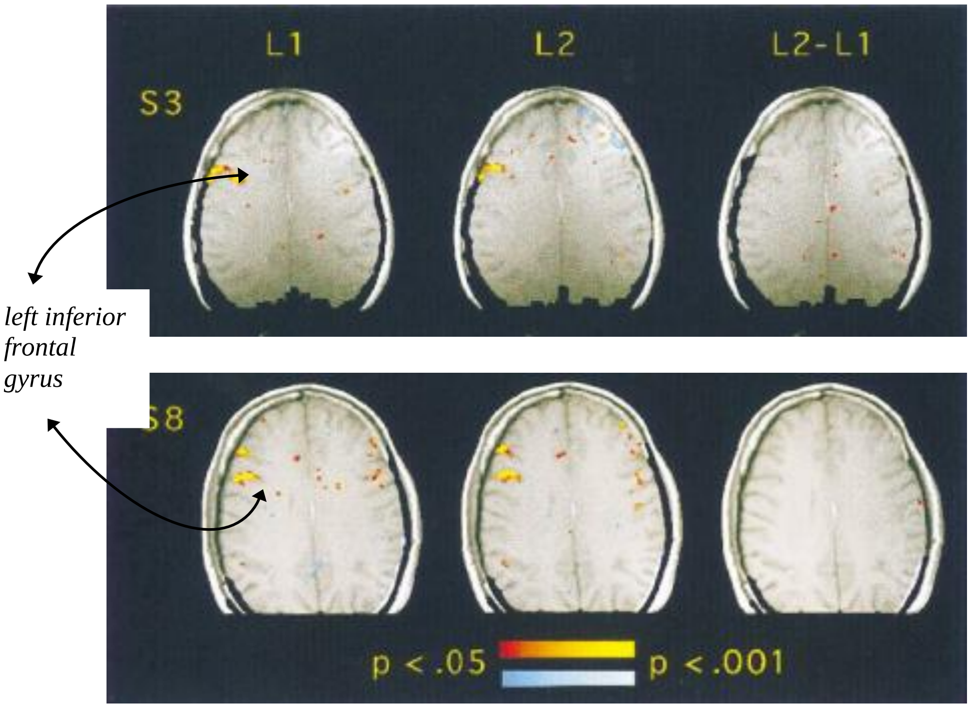


Figure 9. Brain images from two participants showing activation in the left inferior frontal gyrus for semantic processing in English or Spanish (Illes et al., 1999:355).

A study which yielded opposing evidence to the two studies described above was conducted by Ding and colleagues (2003), who investigated the nature of semantic and orthographic processing in Chinese-English bilinguals. The participants were asked to perform an orthographic search task[32] and a semantic classification one, while their brains were scanned through fMRI and it emerged that processing of both languages activated similar brain areas. That is, in the orthographic search task the following areas were active: the left fusiform gyrus, the middle occipital gyrus, the posterior central gyrus, and the left inferior parietal lobule, whereas in the semantic classification task, brain activation was observed in: the left middle and posterior temporal lobe and the fusiform gyrus (Figure 10).

[32] In an orthographic search task participants are asked to indicate whether a particular Chinese character or an English letter is present in a given word or not.

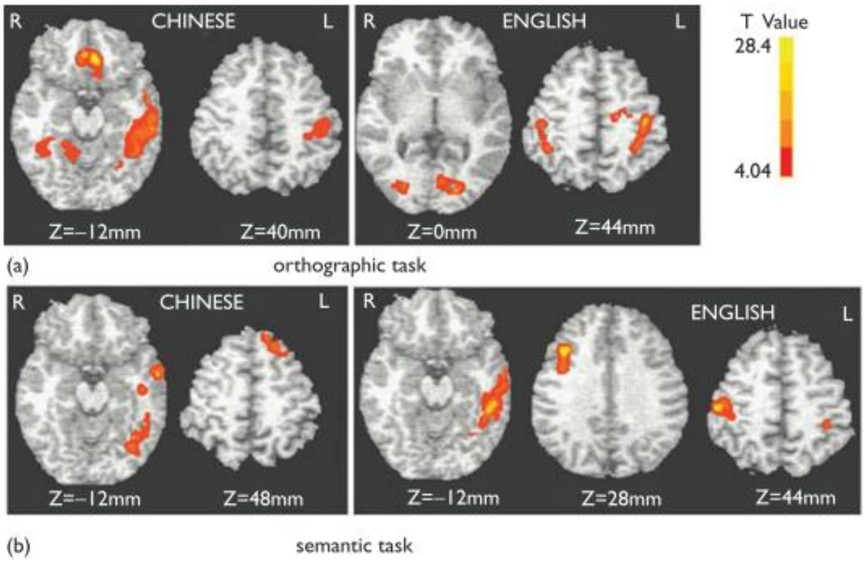


Figure 10. Brain activation patterns observed during (a) an orthographic search task and (b) a semantic classification task (Ding et al., 2003:1560).

However, in both tasks a greater right hemisphere activation was observed when processing English words (L2), rather than Chinese (L1). The findings were in line with the hypothesis that claims greater right hemisphere activation while processing L2. The results presented by Dehaene and associates (1997) also provided support for a variation in activated brain areas for L1 and L2. The authors imaged (fMRI) eight participants' brains while they listened to stories in L1 (French) and L2 (English). The collected data demonstrated that listening to L1 activated a similar set of areas in the left temporal lobe, but while listening to L2 "a highly variable network of left and right temporal and frontal areas" was activated (1997:3809). Dehaene and associates concluded that there is an anatomical variability for the cortical representations of L1 and L2.

The differences in the results obtained in the studies reported above might not necessarily reflect different brain activation patterns. They actually may be attributed to a number of factors, e.g. a choice of task, i.e. a stem completion (Chee et al., 1999), an orthographic search and a semantic classification (Ding et al., 2003) or a listening task (Dehaene et al., 1997). It may also be attributed to the level of the participants' proficiency in L2. For instance, Ding and colleagues (2003) showed greater right hemisphere activation for less proficient language. Nonetheless, it is equally possible that the studies described above actually controlled for different processing mechanisms. An account of this is given in a study conducted by Marian and associates (2003). The researchers asked Russian-English subjects to participate in eye tracking and brain imaging (fMRI) experiments. In the eye tracking experiment the participants were instructed to pick up a target object (e.g. a candy) from a group of objects that included a so called 'cohort object' (an item, which has a name phonetically similar to the target object, e.g. a candle), while at the same time having their eye movements monitored. It was observed that the participants directed their eye movements significantly more often to the between-language competitors[33] rather than to the non-overlapping controls that were placed in the same position (an example of stimuli from a similar study is given in Figure 11).

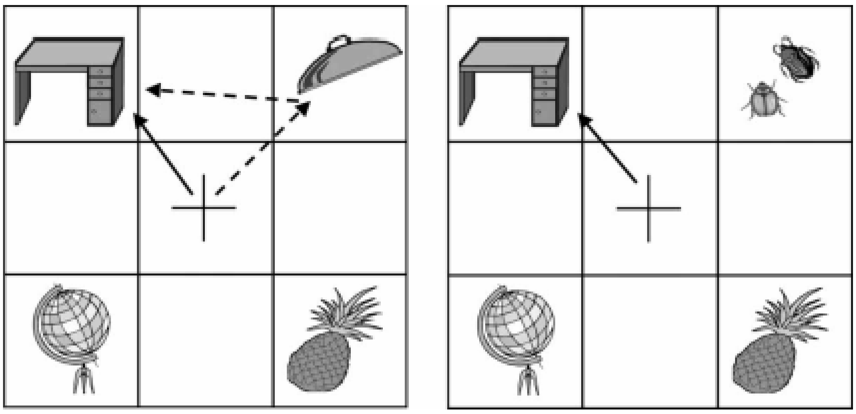


Figure 11. An example of stimuli used by Blumenfeld and Marian (2007:641) in a study with a group of bilingual German-English participants. The left panel presents the competitor condition, whereas the right panel shows the control condition. In this task participants were requested to click on an object with a computer mouse rather than reach for it as in Marian et al. (2003). When participants were requested to click on a 'desk' in the competitor condition, they would gaze briefly towards the lid (Deckel in German), but no such eye movement was observed in the control condition.

[33] The above described eye tracking experiment was performed in a cross-language condition. While the participants were asked to attend to some target objects in Russian, it was observed that they briefly directed their eye sight to similarly sounding "cohort objects' in English, e.g. while asked to pick up a stamp, in Russian 'marku', they would look also at a marker.

Marian and associates (2003) reached the conclusion that languages might be using shared and/or separate structures at different stages of processing. They suggested that "parallel activation […] and shared cortical structures may be characteristic of an early stage of language processing (such as phonetic processing) but the two languages may be using separate structures at a later stage of processing (such as lexical processing)" (ibid, 2003:70). Thus, Marian's and associates contention was that it is crucial to report which level of processing is studied, e.g. orthographic, phonological, or semantic, as this may allow for a clarification of otherwise presumed contradictory findings.

To sum up this section, the psycholinguistic and neurolinguistic evidence presented above seems to support some degree of semantic integration of the two languages in bilinguals. The Stroop interference effect observable in a cross-language condition has revealed the automaticity of language processing and a certain degree of overlap between the semantic level of representation for L1 and L2. The evidence provided from translation studies has shown that different types of words might be stored variously in the memory. Van Hell and de Groot (1998) reported that concrete cognate nouns are stored in a distinct way, different to, e.g. abstract non-cognate nouns or verbs. The picture naming section has further pointed to the conclusion that the level of participants' proficiency and item familiarity may have an impact on how closely items are bound together in the conceptual memory. Finally, the neurolinguistic data has shown that predominantly there is a degree of overlap between neuro-anatomical representation and processing, e.g. phonological processing (Marian et al., 2003). Having discussed the type of information stored at the conceptual level, the focus of this discussion now shifts to two further remaining components: the choice of languages studied, i.e. Chinese and English, and the research methods employed, i.e. the masked priming paradigm and the semantic judgment task.

2.4 Choice of languages

The vast majority of bilingual representation studies have focused on the comparison of bilinguals who speak two Indo-European languages, e.g. Dutch-English participants (e.g. de Groot and Poot, 1997; Kroll and Stewart, 1994; van Hell and de Groot, 1998a), Spanish-English participants (e.g. Altarriba, 1992), and French-English participants (e.g. Smith, 1991; Williams, 1994). Since these languages are closely related and share a number of lexical features, it is difficult to tell whether the conclusions drawn would also apply to "two virtually unrelated languages" (Cheung and Chen, 1998:1112), e.g. Chinese and English. These two languages have a number of unique characteristics that may account for certain differences in the way information in both systems is represented and processed. For instance, Chen (1992, 1996) suggested that the difference in orthography between them may explain the fact that naming is faster than the lexical decision in English, whereas the opposite is true in Chinese. Hence, the need to replicate the findings from Indo-European studies was one of the factors that contributed to the choice of Chinese-English participants in this study.

Furthermore, in 1999, Francis carried out a review of over one hundred studies that had focused specifically on the semantic integration of language and memory in bilinguals. Out of all of those reported from 1958 to 1999, only eleven were conducted with Chinese-English participants. In neurolinguistics, there has been an increase in popularity of comparative investigations with Chinese-English samples since 2000. Also, Li (2013:243), an editor of the Bilingualism: Language and Cognition journal, wrote in his introductory note to a special issue on computational models that "an increasing number of studies have examined bilingual language processing and acquisition in the Chinese–English bilingual context, due to the unique features of the Chinese language and its orthography in comparison to Western languages". It seems that there is an increasing interest in this kind of comparisons. However, psycholinguistic studies with Chinese-English participants are still limited. The scarcity of these types of investigation was another major reason for the choice of Chinese-English bilinguals as the main focus in this project. Moreover, this decision was also driven by the fact that China is currently the second largest economy in the world, the importance of the Chinese language worldwide is steadily increasing, and also the fact that there are a growing number of Chinese-English bilinguals worldwide.

2.4.1 Chinese versus English

Chinese, as a logographic system, and English, as an example of an alphabetic system, differ on a number of levels, e.g. orthographic, phonological, and semantic. However, some similarities between the two languages can be found too. Description of the similarities and differences is given in the coming subsections. Comparison of orthographic and phonological information, even though it is not directly investigated in this study, is included as it has been reported to play an important role in the activation of meanings in both languages (e.g. Perfetti et al., 2005; Perfetti and Tan, 1998, 1999; Perfetti and Zhang, 1991, 1995).

2.4.1.1 Orthography and phonology

Cole and Pickering (2010:501) stated that "the nature of written Chinese is often misunderstood", with Chinese script often being considered to be pictographic[34] in nature (Baron and Strawson, 1976 cited in Cole and Pickering, 2010). However, in modern Chinese less than 1% of characters are pictographic (DeFrancis, 1989). The majority of the characters (about 85%) are semantic-phonetic compounds, i.e. they contain information about both meaning and pronunciation (Perfetti and Tan, 1998; Zhu, 1988). For example, the word *dēng* (燈) (written in traditional Chinese characters),

[34] Pictographs convey meaning through a graphic or pictorial resemblance to a physical object.

which means 'lamp' in English, is an example of such a compound. The left character *huǒ* (火) is a semantic radical[35], which means 'fire'; the right *dēng* (登) is a phonetic component that provides information about the pronunciation of the character (Ho et al., 2003). Thus, according to some researchers, it is more appropriate to refer to Chinese as a logographic, morphemic (e.g. Leong, 1973), or morphosyllabic system (e.g. DeFrancis, 1989; Mattingly, 1992) rather than pictographic.

In Chinese, a character is the basic graphic unit that represents a morpheme. A character comprises usually a number of strokes (from one to twenty) (Ho and Bryant, 1999). The strokes can have different levels of orthographic structure. A combination of strokes can represent: (1) a radical, e.g. *yuè* (月) meaning 'moon' or 'month'; (2) a single complete character, e.g. *rén* (人) meaning 'person'; or (3) a compound character, e.g. *jiā* (家) meaning 'house' or 'family' (a visual representation of how strokes can be combined to form a radical, single character and a compound one is presented in Table 4). Furthermore, very often a stroke is compared to a grapheme in alphabetic systems as a single change of a stroke might alter the meaning of a character, e.g. *xiǎo* (小) meaning 'small' and *shǎo* (少) meaning 'few' or 'little'.

[35] Radicals are the basic components of every Chinese character and there are about 600 recurring radicals that can appear in different sizes at different locations of different characters, e.g. 口 in 狗, 吃, 容 (Ho and Bryant, 1999).

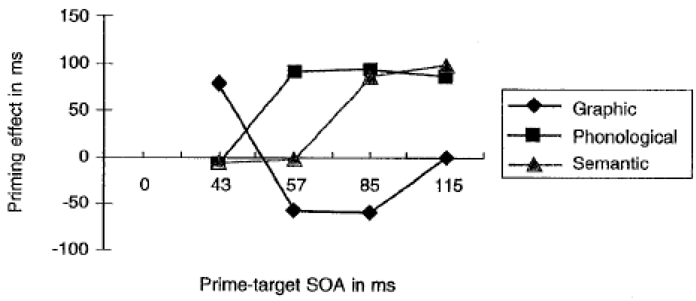
different levels of orthographic structure	**examples [English translations]**
compound and single characters combined into words/phrases	中国人 [Chinese person]
compound character	国 [country]
radical / single character	囗 [enclosure]
stroke	丨 [link]

Table 4. A representation of the different levels of the orthographic structure of Chinese characters.

It is also important to note that the characters in Chinese do not have a linear structure. That is, they have a square composition and are traditionally read from right to left, from the top of the page to the bottom. In comparison, English is an example of an alphabetic language in which words are made up of letters and there is a direct but complex mapping of graphemes to phonemes. As pointed out by Ziegler and colleagues (1997), 75% of English words have a consistent mapping of orthography to phonology. The letters are organized from left to right in a linear structure and the array of simple units/letters makes more complex units, i.e. words, phrases, and sentences (Perfetti et al., 2002).

Phonology is seen as an important component in the written word identification process in both Chinese and English (Perfetti et al., 2002). Perfetti and Zhang (1991, 1995), and Perfetti and Tan (1998:114; 1999) demonstrated that it is a constituent part of the "psychological moment of identification", observable across writing systems and is activated at the moment of orthographic recognition. The orthography of a writing system, however, determines the way in which phonology is activated (Shen and Forster, 1999). In Chinese, it is seen as being activated in a *threshold style,* whereas in English this is in a *cascade style* (Coltheart et al., 1993). In Chinese, word-level phonology is activated once a full orthographic specification of a character has been made and often that of the individual strokes that the character comprises does not reflect the phonology of the actual character. In English, on the other hand, letter-level phonology is activated prior to word-level (Perfetti et al., 2002), i.e. individual letters or syllables can be sounded out and when combined together they produce the phonology of the word. Some researchers (e.g. Cheng, 1992; Tan et al., 1995) have argued, however, that in Chinese "the phonological information represented in the phonetic component [in compounds] may allow for […] phonological recording in much the same fashion as in alphabetic languages" (Shen and Forster, 1999:433). Nonetheless, as indicated by Zhu (1988), only 18.5% of commonly used Chinese characters are phonologically transparent, i.e. the phonetic component has the same pronunciation as the whole character. Thus, it is not possible to rely, in a consistent way, on this type of information for the pronunciation of Chinese characters. Furthermore, the two languages differ also at the level of sublexical units. The sublexical components in Chinese are very often characters themselves, whereas in English, letters are constituent parts of words. As explained by Perfetti and colleagues (2005:56), the duality of characters (lexical and sublexical) plays an important role in processing, i.e. " [the] duality could be the main difference responsible for the cascade versus threshold difference."

Due to the discrepancies in the two levels of representation between Chinese and English, it has been suggested that orthography may play a more central role while processing information in Chinese, whereas, phonology may be more relevant in English. For example, Chen and colleagues (1995:152) demonstrated, with the use of a semantic categorization task, "that the meaning representation of Chinese characters seems to be activated on the basis of orthographic information. […] [whereas] phonological information does not seem to play a critical role in the activation of the meaning of Chinese characters, although it may play a greater role in the semantic processing of words written in an alphabetic-writing system." Also Wong and Chen (1999:476), using eye-monitoring technique, provided evidence that orthography plays a more dominant role in the early stage of Chinese word processing. The phonological processing was also seen as relevant but "too slow and weak to affect the early stages of processing." On the other hand, Perfetti and Zhang (1991, 1995) and Perfetti and Tan (1998, 1999) provided evidence that phonological activation is universal to all languages, concluding that it occurs early [36] and constrains access to semantic information. In Chinese, however, orthographic facilitation is followed by orthographic inhibition with a simultaneous phonological facilitation, whereas in English both orthography and phonology have been observed to rise together (Figures 12) (Perfetti and Bell, 1991; Perfetti et al., 2005).



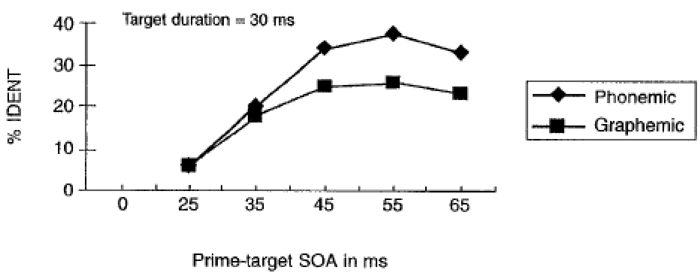


Figure 12. Figure 12 (top) illustrates data obtained from a primed naming task in Chinese (Perfetti and Tan, 1998). Figure 12 (bottom) shows data obtained from a primed identification with a masking task in English (Perfetti and Bell, 1991) [figure from Perfetti et al. (2002:42)].

[36] Phonology emerges in less than 90ms in a semantic task (Perfetti and Zhang, 1995) and in less than 60ms in a naming one (Perfetti and Tan, 1998).

2.4.1.2 Semantics

As noted above, many compound characters contain both the semantic and phonetic information; however, even though it can be useful, it is not very reliable. Most compound characters have a degree of semantic validity[37] but this is dependent on the printed frequency of the compound character (Perfetti et al., 2005). That is, Perfetti et al. (1992) demonstrated that semantic validity increases with decreasing printed frequency of compounds in Chinese. Additionally, due to the fact that a limited number of characters are used (presently about 4500), each Chinese character has acquired multiple meanings. That is why retrieving meanings of some characters presented aurally in isolation can turn out to be complicated (Tan et al., 2000). English, like Chinese, is also not a semantically transparent language, for the relationship between orthography and meaning is mainly arbitrary (Booth et al., 2006). For instance, if we are presented with the English word *agraffe*[38] for the very first time, there is no way of knowing the meaning of it from the orthographic or phonological information. However, if we look at compound words in English, the meaning of some compounds can be inferred from their components. For example, in endocentric compounds, the meaning can be guessed from the analysis of its morphemes, e.g. *car-wash*. By contrast, the meaning of English exocentric compounds cannot be established by an analysis of parts, e.g. *hogwash* (Libben et al., 2003). Thus, it can be concluded that semantic information in Chinese and English is not easily available from the surface structure of a character or a word.

Furthermore, as demonstrated in the previous subsection (2.4.1.1), both orthographic and phonological information play an important role in the processing of Chinese and English words. The information, however, is processed in a slightly different way (in a

[37] Semantic validity indicates that some aspect of meaning is suggested by a semantic radical that forms a part of a compound character (Perfetti et al., 2005).
[38] One of the meanings of the word *agraffe* refers to the wire that holds the cork in a champagne bottle.

naming task and identification one[39]). The differences observable at the lexical level (in orthography and phonology) may have an impact on semantic processing and thus, it would be interesting to see if this processing of the two languages is similar or not. To examine this, Chee and colleagues (2000) used fMRI to investigate the semantic processing of Chinese characters, English words and pictures. The researchers tried to determine if the semantic processing of Chinese characters resembled picture-like or word-like processing. The research question addressed was based on the difference in scripts (logographic versus alphabetic) and the suggestion that the meaning of Chinese characters may be more easily predictable than it is for English words (Smith, 1985). Chee and colleagues asked six Mandarin-English bilinguals to perform two matching tasks: a size judgment task[40] and a semantic one[41], while at the same time their brains were scanned with fMRI. The comparison of the results revealed that semantic processing of characters, words, and pictures activate a common network (i.e. left prefrontal, left posterior temporal, left fusiform gyri, and left parietal region). Even though the activated areas were similar, there was an observable difference in modality activation. The researchers concluded that "Chinese characters semantic processing shares greater similarities with English word semantic processing than with picture semantic processing" (ibid., 2000:400). The finding that Chinese characters are processed like words rather than pictures is an important one because it allows for a comparison of both systems, despite the conspicuous differences.

[39] In an identification task, participants are asked to recognize target words that are presented very briefly, e.g. Perfetti and Bell (1991) used 35ms, 45ms, and 55ms of target duration display.
[40] As explained by Chee et al. (2000:393) in a size judgement task, one of the items was e.g. 6% smaller or larger than the sample item and the other was 12% smaller or larger. Participants were instructed to choose the item that was closer in size to the sample stimulus.
[41] As explained by Chee et al. (2000:393), in a semantic task the participants are instructed to choose the item closer in meaning to the sample stimulus.

Additionally, Chen and Ng (1989) investigated semantic and translation priming effects[42] in Chinese-English bilinguals with the use of a lexical decision task (LDT). The researchers selected a group of Chinese-English bilingual speakers, for they believed that the differences between the two languages may reveal some relevant information about linguistic universals[43]. The collected data showed both translation and semantic facilitation effects. The findings were comparable to previous studies conducted with Indo-European samples (e.g. Schwanenflugel and Rey, 1986; or Vanderwart, 1984 cited in Chen and Ng, 1989). Thus, Chen and Ng (1989:461) summed up that “mental processes involved in the semantic priming paradigm and the LDT are universal, and independent of between-language distance.” Correspondingly, Francis (Francis, 1999:214), based on a review of over one hundred studies, concluded that “any difference among language combinations are due to the nonsemantic components of the tasks, orthography in particular, rather than to different degrees of semantic integration.” The researcher further stressed the fact that comparative studies that focus on phonological, orthographic, syntactic, or morphological processing should be more attentive to the particular combination of languages, but not those studies that focus on semantic processing.

All in all, despite a number of noticeable differences between the two languages, some similarities between Chinese and English can be found too. For instance, both orthography and phonology play an important role in the processing of Chinese and English words (Perfetti and Zhang, 1991, 1995; Perfetti and Tan, 1998, 1999). Furthermore, it has been reported that the semantic processing of both language systems is done similarly (Chee et al., 2000) and the distance between the two languages does not

[42] A priming effect is understood as a facilitative change in RT. A detailed description of the effect is presented in subsection 2.5.1 of this chapter.

[43] Linguistic universals are a set of patterns that occur systematically in most languages.

have impact upon the universal mental processes (Chen and Ng, 1989). Hence, the processing and representation of semantic information in Chinese-English bilinguals is investigated in this project with the use of a masked priming task and a detailed description of the selected paradigm is provided in the next section of this literature review.

2.5 Implicit masked priming

From the vast array of tasks commonly employed in the bilingual representation studies, e.g. picture naming, translation, Stroop interference, and semantic categorization, the masked priming paradigm (Forster and Davis, 1984) was selected for this project. As pointed out by Grainger (2008:9) "in the last two decades masked priming has become a key tool for studying all aspects of visual word recognition, using both behavioural measures of performance and also more direct measures of brain activity." However, the popularity of the task was not the only reason for selecting it in this research, for it also allows exploration of how words are stored and connected in the memory as well as measuring automatic cognitive processes (Altarriba and Basnight-Brown, 2009). In masked priming, the primes are presented at such a quick interval that participants tend not to be aware of them. They can only consciously recall target words. Therefore, masked priming allows for the elimination of translation strategies and at the same time it encourages on-line processing (Kim and Davis, 2003).

2.5.1 Priming paradigm

The rationale behind the priming paradigm is that a prime (briefly presented first word) should activate other words that are semantically and associatively related to it and/or translation equivalents. Hence, a target (a word presented as second) should be recognized more quickly, i.e. a priming effect, if its antecedent (prime) is semantically related, is its associate or translation equivalent in a cross-language paradigm. In other words, “when a word is recognized [in a priming task], not only is its meaning automatically activated, but activation spreads to those words that are semantically related to or associated with the presented word” (Altarriba and Basnight-Brown, 2009:81). The priming effect is usually measured as “an item-specific change in RT, accuracy, bias, or attribution in task performance based on previous experience” (Francis et al., 2010a:187). It is possible to distinguish between three different types of priming designs and procedures (Jiang, 1999). In the earlier studies (e.g. Kirsner et al., 1984), priming usually involved a two-phase design, i.e. a study phase and a test phase. First, participants were exposed to words in one language (study phase) and next they were asked to perform a task in the other language (test phase). The priming effect was measured as the difference in reaction times between studied and non-studied pairs of words. However, because of a long time lag between the presentation of primes and targets, this design was considered problematic (Chen and Ng, 1989; de Groot and Nas, 1991). Later, a single-phase design was adopted (e.g. Chen and Ng, 1989; Jin, 1990), in which targets followed primes in a rapid manner (in most studies the interval was less than one second) (Jiang, 1999). In this design, both the prime and target are visible to participants and therefore it may lead to the use of conscious strategies like translation, thereby not measuring what is intended, i.e. the automatic processing of language. Thus, to minimize the use of translation strategies, a mask has been introduced in more recent priming studies (e.g. de Groot and Nas, 1991; Gollan et al., 1997). A mask, e.g. usually a row of ten cross hatches (##########) presented before the prime (forward mask) and/or after the prime (backward mask), prevents participants from consciously perceiving the prime, which is typically presented for as short as 50ms (Jiang, 1999). To exemplify the importance of using a mask, Jiang (1999) summarised published data from several studies that used nonmasked and masked priming paradigms (Table 5).

task	L1 to L2	L2 to L1
nonmasked		
Chen and Ng (1989)	150	165
Jin (1990)	150	36
de Groot and Nas (1991)	113	-
Altarriba (1992)	70, 76	17, 52
Keatley et al. (1994)	66	34
masked		
de Groot and Nas (1991)	35, 40, 22	-
Sanchez-Casas et al. (1992)	-	-8
Gollan et al. (1997)	36, 52	9, -3
Jiang (1999)	45, 6	13, 3, 4, 7, -2

Table 5. A summary of translation priming magnitudes in milliseconds under nonmasked versus masked conditions (adapted from Jiang, 1999).

As we can read from Table 5, the difference between priming magnitudes is considerable for both types of paradigms, with priming effect reported in masked condition being much smaller than nonmasked. More specifically, the magnitude of the priming effect in an L1 to L2 masked condition varies from 6ms to 52ms, whereas for the nonmasked condition the effect diverges from 66ms to 150ms. In the L2 to L1 masked condition the priming effect results are very small, some of them even negative, which could suggest an inhibitory effect rather than facilitative one. In the L2 to L1 nonmasked condition a priming effect was observable and varied from 17ms to 165ms. This finding again shows the importance of carefully controlling for a task-type as well as the design.

As mentioned in the introduction to this section, priming allows measuring automatic language processing. However, in order to be able to show the automaticity of priming, the following elements have to be carefully controlled for: stimuli onset asynchrony (SOA)[44], nonword ratio (NWR)[45] in an LDT, and relatedness proportion (RP)[46]

[44] SOA is the amount of time between the presentation of the prime and target (Altarriba and Basnight-Brown, 2009).
[45] NWR is the proportion of nonword trials to word trials in each word list in an LDT (Altarriba and Basnight-Brown, 2009).

(Altarriba and Basnight-Brown, 2007, 2009; Basnight-Brown and Altarriba, 2007). All of these components, if carefully controlled for, should reduce the more conscious mechanisms observable during a priming task, i.e. the expectancy strategy and the semantic-matching strategy (Neely, 1991; Neely et al., 1989). The first of these mechanisms refers to a situation during which a list of related words is mentally constructed before a target is presented and such may occur due to the RP being too high and/or the SOA too long. The second mechanism is a form of post-lexical checking that takes place once the target has been displayed. If the RP is high, the participants might be distracted by (unintentionally) thinking about related words that may or may not be included as later targets, rather than automatically processing the next prime-target pair. Thus, in order to minimize the use of conscious strategies, it is crucial to control for the RP and to make sure that the SOA is kept short, i.e. under 200ms[47] (Altarriba and Basnight-Brown, 2007, 2009; Basnight-Brown and Altarriba, 2007). Furthermore, additional methodological issues need to be taken into consideration when designing priming experiments. Elements such as word length and frequency, use of mask[48], and use of an interstimulus blank space have to be carefully controlled for. For instance, it has been shown in several monolingual studies (e.g. Balota and Chumbley, 1985; Raveh, 2002) that the length and frequency of primes and targets can affect the speed of word processing and recognition and therefore influence the priming effect obtained. Furthermore, introducing an interstimulus blank space may result in so called *ghosting effects*, i.e. a subjective experience that the presented stimulus is still visible on the screen when it is no longer there (Finkbeiner, 2005). That is why a backward mask is commonly introduced as “distinct visual stimuli” (ibid, 2005:743).

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[46] RP is the proportion of related trials to unrelated trials in each word list (Altarriba and Basnight-Brown, 2009).

[47] Boden and Masson (2003) revealed that the RP effect is usually absent if the SOA is less than 300ms, and Hutchison et al. (2001) manipulated its length reporting that word processing was no longer affected by the RP when the SOA was around 167ms.

[48] The importance of controlling for the use of a mask is exemplified by the data outlined in Table 5 and the discussion that follows.

The studies carried out by Basnight-Brown and Altarriba (2007) and Schoonbaert et al. (2009) have demonstrated that highly constrained experimental procedures, i.e. use of a mask, and short SOA, allow for minimizing the use of strategic processes and observing the semantic and translation priming effect from both L1 to L2 as well as from L2 to L1. Basnight-Brown and Altarriba (2007) conducted two priming experiments with Spanish-English bilinguals, carefully controlling for SOA and masking. The researchers reported facilitation in both translation directions during translation priming and significant semantic priming from the L2 to L1 direction, if the primes were unmasked and the SOA was around 100ms (experiment 1). When a forward mask was introduced (experiment 2), the facilitation effect disappeared in semantic priming but was still visible in translation priming, thereby demonstrating that "translation word pairs elicit more activation than do semantically related word pairs, suggesting that strict semantic-priming effects may not be capable of producing cross-language semantic priming effects when the experimental design is highly constrained" (ibid., 2003:963). Furthermore, Schoonbaert et al. (2006 cited in Altarriba and Basnight-Brown, 2009) in a study with Dutch-English bilinguals, reported semantic priming in both processing directions, but only for concrete nouns not abstract ones. This confirms that not only do the experimental conditions have an impact on the results reported but also the selected stimuli.

2.5.2 Priming paradigm in the form of a conceptual implicit memory task

Durgunoğlu and Roediger (1987) were probably the first to provide empirical evidence supporting the finding that task demands determine the type of data obtained. The researchers worked with a group of Spanish-English bilinguals who showed evidence of both language-independent and language-specific results in a word fragment completion task[49] and a free recall task[50]. This pattern of results led Durgunoğlu and Roediger to

[49] In a word fragment completion task, participants are presented with parts of previously studied words and are asked to complete them.

distinguish between *data-driven tasks* and *conceptually-driven tasks*. The former are believed to tap into the lexical level of information, the latter into the conceptual level (the findings reported by Durgunoglu and Roediger (1989) are summarised in Table 6).

	two types of tasks	
paradigm	word fragment completion	free recall
type of paradigm	data-driven task	conceptually-driven task
findings	language-specificity/dual code	language-independence/single code

Table 6. A comparison of the findings from two types of tasks (adapted from Durgunoglu and Roediger, 1989).

The distinction between data-driven and conceptually-driven tasks is highly relevant as it supports the researchers' contention that varying retrieval demands of different tasks produce distinct results. For instance, use of a word fragment completion task may result in supporting language specificity; however, when a free recall task is administered language independence might be accounted for. The above presented findings were also addressed by Zeelenberg and Pecher (2003). In five experiments the researchers tested the hypothesis that a cross-language repetition/translation priming effect[51] can be found in tasks that rely on conceptual processing, but not in lexical processing based ones. The researchers reported that some of the previous studies failed to obtain this effect, as they employed tasks that were *conceptual* in nature, not *conceptual.* As explained by Zeelenberg and Pecher (2003:2) "performance in *conceptual* tasks relies primarily on the processing of the physical attributes of the presented stimuli whereas performance in *conceptual* tasks relies primarily on the processing of the semantic attributes of the presented stimuli." For example, the repetition priming effect was not found consistently in an LDT (e.g. Kirsner et al., 1984). According to Gollan and Kroll (2001), this lack of priming effect might be due to the fact that performance in an LDT relies primarily on

[50] In a free recall task, first participants are asked to memorize a list of words, next they are requested to recall from memory the studied words.
[51] A cross-language repetition priming effect is interpreted as supporting shared conceptual representations for translation equivalents.

lexical processing, i.e. on the word form-level and hence to be able to decide if a presented string of letters is a word or a nonword, it is not necessary to understand the meaning of the stimuli.

Zeelenberg and Pecher (2003:2) further indicated that a task employed to study the conceptual level of information must be implicit in nature to avoid a situation in which "memory performance might be influenced by translation strategies." Thus, they concluded that repetition priming should be observed in an implicit memory task that depends on *conceptual* processing, like: a man-made decision[52], an animacy decision[53], a free association[54] or a category-exemplar production[55]. Zeelenberg and Pecher (2003) used two of these tasks, i.e. an animacy decision task and a man-made decision task alongside an LDT, to demonstrate a priming effect and thus evidence for shared conceptual representations can be obtained when carefully controlling for the type of task. Similar findings were obtained by Li and colleagues (2009), who worked with Chinese-English bilinguals of low language proficiency. They used a primed animacy decision task (living versus nonliving) and contrasted it with an LDT (word versus nonword) to show that task type indeed impacts on the results obtained. Additionally, Kim and Davis (2003) requested Korean-English unbalanced bilinguals to perform a primed LDT, a naming task and a semantic categorization task. The researchers manipulated the nature of the relationship between primes (Korean) and targets (English), with the pairs of words sharing: (1) semantics and phonology (cognate translations); (2) semantics only (non-cognate translations); (3) phonology only (homophones); or (4)

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[52] In a man-made decision task, participants are asked to indicate whether a presented word is an example of something man made (e.g. car) or something not made by a man (e.g. tree).

[53] In an animacy decision task, participants are requested to recognise if a presented word is a living (e.g. penguin) or a non-living exemplar (e.g. stone).

[54] In a free association task, words are presented on the computer screen and the participants are requested to write down the first word that comes to their mind after seeing the stimulus.

[55] In a category-exemplar production task, participants are given the name of a superordinate category (e.g. animals) and are asked to produce the first few examples that come to their mind (e.g. dog, cat, mouse, etc).

neither semantics nor phonology (baseline). The results varied considerably. For example, a cognate and non-cognate translation priming effect was observed in the lexical decision and semantic categorization[56] but not in the naming task. Instead, in the naming task, cognate and homophone primes produced a significant effect. Thus, Kim and Davis (2003) concluded that both task type and prime-target relationship affect the priming effect.

In order to ensure that the semantic level of information was measured in this study a careful decision had to be made about the choice of priming paradigm. An animacy decision task was selected in the form of a masked priming paradigm since it is *conceptually-driven* (Durgunolu and Roediger, 1987) and implicit in nature (Zeelenberg and Pecher, 2003). A detailed description of the paradigm employed in this project is presented in section 3.3 of chapter three.

2.5.3 Priming asymmetry effect

The cross-language repetition/translation and semantic priming effect has been reported to be asymmetrical. This means that it tends to be stronger from L1 to L2, but weak and inconsistent from L2 to L1 (e.g. Chen and Ng, 1989; Finkbeiner et al., 2004; Gollan et al., 1997; Jiang, 1999; Jiang and Forster, 2001; Jin, 1990; Kim and Davis, 2003; Voga and Grainger, 2007). To exemplify the above point, Schoonbaert and collaborators (2009) compared the priming effects of twenty-six experiments carried out in thirteen studies (a brief summary of the findings is presented in Table 7). The pattern of results is surprising as it shows that on average L1 to L2 priming is 20ms longer in duration compared to the L2 to L1 priming effect.

[56] Kim and Davis (2003) reported a 36ms priming effect in the LDT and 55ms in the semantic categorization task.

studies	L1 - L2	L2 - L1
Basnight-Brown and Altarriba (2007)	33*, -8	24*, 6
de Groot and Nas (1991)	35*, 40*, 22*	-
Duyck (2005)	33*	20
Duyck and Warlop (2009)	48*	26*
Finkbeiner et al. (2004)	-	-4
Gollan et al. (1997)	36*, 52*	9, -4
Grainger and Frenck-Mestre (1998)	-	-4, -3, 2, 10
Jiang (1999)	45*, 68*	13*, 3, 4, 7, -2
Jiang and Forster (2001)	41*	4, 8
Kim and Davis (2003)	40*	-
Perea et al. (2008)	11*, 19*,	15*, 17*
Voga and Grainger (2007)	23*	-
Williams (1994)	21*, 45*, 45*	-

Table 7. A comparison of translation and semantic priming effects in milliseconds on lexical decision reaction times (* $p < 0.05$) (adapted from Shoonbaert et al., 2009).

Various representational and processing accounts have been put forth to account for the asymmetry effect. The representational hypothesis (based on the theoretical predictions of the RHM) explains the findings in terms of the different strengths of interlexical connections between the two languages. According to the RHM (Kroll and Stewart, 1994), semantic priming effects from L1 to L2 should be stronger than from L2 to L1 since the connections between L1 and concepts are stronger than those for L2 and concepts (Figure 4 in subsection 2.2.1.3, chapter two). In other words, the representational account implies that if an L1 word is presented as the prime, then it would activate more conceptual information, and consequently, a greater amount of conceptual activation would be spread to the target L2 word, whereas the same pattern is not true for the reverse direction (Basnight-Brown and Altarriba, 2007:956). In addition to the representational hypothesis, there are several processing accounts that have been put forth. For instance, Grainger and Beauvillain (1988) suggested that the time that is given for L2 prime processing may not be enough for the participants to be able to recognize it, especially if the level of L2 proficiency is low. A second account presented by Gollan and colleagues (1997) refers to the different processing speeds in the two languages. It has been suggested that the L2 prime might be processed more slowly than the L1 target. For example, the latter may be accessed before the former if there is a very short interstimulus interval between the two words. This, however, does not exclude the recognition of the L2 prime, which can still be recognized, but too slowly to produce an L2 to L1 priming effect (Jiang, 1999). The third processing explanation, the general activation level hypothesis, has to do with the fact that a bilingual's dominant language, usually L1, is stronger/more proficient. If we assume that L2 is less dominant, then an L2 prime would be less active and less available for processing than an L1 one. Jiang (1999) tested these three processing hypotheses with a group of Chinese-English bilinguals. He used a masked priming paradigm, varying the presentation conditions of primes and targets by introducing a 50ms blank interval (experiment 3); by introducing a 150ms backward mask (experiment 4); and by presenting targets in two languages in a single block (experiment 5) in order to increase the activation level of L2 primes. He found a strong translation priming effect in the L1 to L2 language condition, but the priming effect in the L2 to L1 condition was reduced or not visible at all, even when the experimental conditions were varied, i.e. a blank interval of 50ms was introduced or the SOA was increased to 250ms to allow more time for L2 prime processing. Therefore, Jiang (1999:72) concluded that the three processing accounts are not satisfactory and "a representation-oriented approach seems to be in a better position to explain the asymmetry." Consequently, the representation account outlined by the RHM is researched in this project.

Furthermore, there have been several other perspectives adopted to address the priming asymmetry effect. For instance, Finkbeiner and colleagues (2004), who worked with Japanese-English participants, tried to explain the masked priming asymmetry with reference to the Sense Model (Figure 13). They believed that the priming effect is unequal as the number of activated senses/meanings differs for each processing direction, i.e. the activation from L1 to L2 is greater (many-to-few-sense words direction), than the activation from L2 to L1 (few-to-many-sense words direction). The researchers explained that "this is because it is frequently the case that there are many senses associated with the L1 form that are not similarly associated with the L2 prime" (ibid, 2004:9). Therefore, significant facilitation is consistently observed in the L1 to L2 direction but less frequently so in the opposite way. In order to be able to show priming effects in both language directions, i.e. from L1 to L2 and L2 to L1, in this project, words that have only one dominant translation equivalent are selected (few-sense-to-few-sense words). This measure should allow for a strong activation of related targets both when presented in L1 and L2.

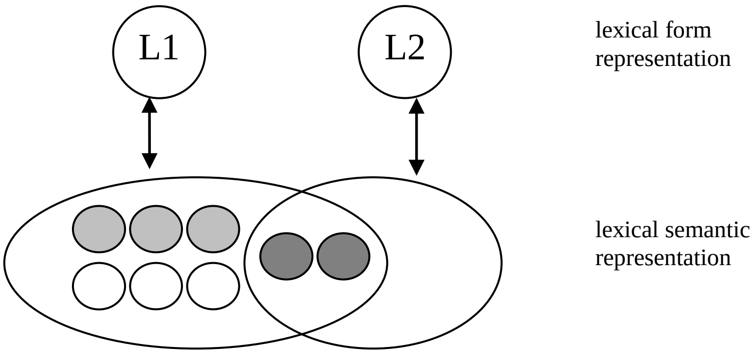


Figure 13. The Sense Model (adapted from Finkbeiner, 2004), L1 stands for first language, L2 stands for second language. Shared senses between L1 and L2 are shown in dark grey. Language specific senses are shown in white and light grey.

All in all, Schoonbaert and colleagues (2009) stated that differences observed in priming tasks are of a quantitative nature rather than their being qualitative. In other words, the priming effect is observable both from L1 to L2 and from L2 to L1, but it differs in strength. Based on the overview of previous studies and their own experiments (a translation priming – experiments 1 and 2; a semantic priming – experiments 3 and 4), Schoonbaert et al. (2009:580) summarised the masked cross-language priming effect findings by saying that "the priming effect is larger for translation priming than for semantic priming; it is slightly (but not significantly) larger for concrete words than for abstract words; and it is larger for a long SOA than for a short SOA." Thus, it might be assumed that translation primes share more conceptual nodes than semantically related ones and that concrete words have a greater semantic overlap than abstract words (findings in line with the Distributed Feature Model proposed by van Hell and de Groot, 1998a).

2.5.4 Priming in languages with different scripts

The priming facilitation effect is commonly observed not only when comparing languages that are fairly similar to each other, but also when comparing languages with highly distinct orthographies, e.g. Chinese-English (e.g. Chen and Ng, 1989; Dong et al., 2005; Jiang, 1999; Jiang and Forster, 2001; Li et al., 2009; Wang, 2013; Wang and Forster, 2010); Korean-English (Kim and Davis, 2003); Japanese-English (Finkbeiner et al., 2004); Hebrew-English (Gollan et al., 1997; Tzelgov and Eben-Ezra, 1992); and Greek-French (Voga and Grainger, 2007). The findings reported by these studies suggest that semantically related words and translation equivalents are somehow interconnected even across highly dissimilar languages (Wang and Forster, 2010).

The priming asymmetry effect has also been observed in research investigations that focused on languages with different scripts. For instance, Gollan and associates (1997) investigated the translation priming effect with Hebrew-English participants with the use of cognate and non-cognate[57] words. The researchers found significant priming effects for both types of words, but only with L1 primes. When primes were presented in L2, Gollan and colleagues reported weak and inconsistent priming. The same pattern of results was reported by investigations with Chinese-English participants (e.g. Jiang, 1999;

[57] Non-cognate words are translation equivalents that are dissimilar in terms of orthography and phonology, e.g. English *apple*, Chinese *píngguǒ* (苹果).

Jiang and Forster, 2001), i.e. robust priming from L1 to L2 and a weak priming effect in the opposite direction. Although these findings are consistent with same-script studies, they do differ slightly. First, in different script studies, the priming effect, in L1 to L2 condition, has been reported for both cognate and non-cognate words. Second, the priming effect for the L2 to L1 condition seems to be less strong when the scripts of the two languages vary[58]. For instance, the findings reported by Gollan and associates (1997) were contradictory to those previously presented by the same-script studies. That is these researchers demonstrated a priming effect for non-cognate Hebrew-English translation equivalents; whereas de Groot and Nas (1991) showed only a weak non-cognate priming with Dutch-English bilinguals and Sanchez-Casas and colleagues (1992) who worked with Spanish-English bilinguals did not elicit a non-cognate priming effect. Therefore, Gollan et al. (1997) came to the conclusion that orthography must play a relevant role in lexical access. The researchers adopted the view that presenting primes and targets in different scripts provides a powerful orthographic cue, which "permits more rapid access of the relevant lexicon and increases the probability that the prime will be accessed quickly enough to influence the processing of the target" (ibid., 1997:1134). The orthographic cue hypothesis, as the above presented account is known, provides an explanation for the priming effect observable when non-cognate words are used, however it does not provide an explanation for the priming asymmetry effect. An account given by Schoonbaert and colleagues (2009) offers a possible explanation of the discrepancy. The researchers explained that in a situation when two languages have the same script, many of the early word recognition processes, e.g. letter identification or phonological coding, can be shared between L1 and L2. In a way, the L2 target can use the already operating L1 *machinery* of language processing. Also, Grainger and Frenck-Mestre (1998:615) confirmed that "primes sharing orthography and/or phonology with

[58] The summary of priming studies presented by Schoonbaert et al. (2009) clearly exemplifies the difference in asymmetry effect strength between same-script and different-script studies.

the target word can facilitate target processing via the partial activation of the target word's form representation during prime processing, as well as via activation of sublexical representations (e.g. letters or phonemes) shared by prime and target." On the other hand, targets presented in a different script to primes need more time for activation as the two scripts rely on different processes. Hence, the L2 to L1 priming effect reported in different script studies is smaller than that reported in their counterparts.

2.5.5 Priming in the visual and auditory modalities

Previous priming studies that focussed on Chinese-English bilinguals have so far been limited to visual word recognition (e.g. Chen and Ng, 1989; Dong et al., 2005; Jiang, 1999; Jiang and Forster, 2001; Li et al., 2009; Wang, 2013; Wang and Forster, 2010) despite the conspicuous difference in scripts, which could push participants into a bilingual mode (Grosjean, 1998) and skew results. Both auditory words and visual words share the same concepts, i.e. they convey the same meaning. They also "retain the same identity in terms of their syntactic, phonological, and orthographic word forms" (Francis et al., 2010b:788). Nevertheless, the physical properties of spoken and written language differ and the auditory and visual stimuli may "engage different neural systems in modality-specific brain regions" (Anderson and Holcomb, 1995:177). Hence, this researcher decided to employ both visual and auditory stimuli, thus allowing for the evaluation of previous results and for a possible generalizability of findings.

A number of early studies (e.g. Bradley and Forster, 1987; Forster, 1976) suggested that the recognition of printed and spoken words is mediated by the same underlying processes. Auditory and visual word recognition was believed to rely on similar basic processes of memory and categorization (Goldinger et al., 1992). However, some other studies have reported an asymmetry between the two modalities. For instance, Holcomb and Neville (1990) compared semantic priming in the visual and auditory modalities using event-related brain potential (ERP) and behavioural measures (error rates and RT). The researchers reasoned that the behavioural and electrophysiological findings should be alike for semantic priming in visual and auditory modalities if the mechanism is similar. To test this theoretical assumption, Holcomb and Neville recruited a group of sixteen native English speakers[59] and asked them to perform a primed LDT. The task comprised primes and targets of varied relationship. Primes were followed by semantically related words, unrelated words, pseudowords[60] and nonwords[61]. The results revealed a robust semantic priming effect in both visual and auditory conditions. Also, the recorded N400 amplitude was smaller[62] when related target items rather than unrelated words were presented in both visual and auditory modalities. However, the ERP and RT priming effects in the auditory condition were significantly larger than those from the visual task (Table 8); they were distributed differently on the scalp; and they differed in time course of the N400 effect.

	related words	**unrelated words**	**pseudowords**	**nonwords**
		visual		
RT	653 (92)	686 (79)	808 (103)	630 (74)
% errors	0.5 (1.0)	1.6 (1.8)	2.8 (2.8)	0.7 (1.3)
		auditory		
RT	718 (89)	827 (87)	932 (110)	716 (85)
% errors	0.4 (1.0)	1.8 (1.6)	3.8 (3.0)	0.4 (0.8)

Table 8. A comparison of mean RT and error rates from two modalities. Standard deviations are shown in parentheses (adapted from Holcomb and Neville, 1990)

As we can observe in Table 8, in the visual modality, the participants responded to the related stimuli approximately 33ms quicker than to the unrelated words, whereas in the

[59] Since there are no bilingual studies (known to this researcher), which compared the two modalities in a semantic priming paradigm, a decision was made to provide evidence from monolingual investigations.
[60] Pseudowords are nonwords formed in accordance with the orthographic and phonological rules of a given language (Holcomb and Neville, 1990).
[61] Nonwords are non-existent words that are created by changing one of the letters in an original word, e.g. word *apple*, nonword *appke*.
[62] Smaller N400 amplitude is expected when primes and targets are related. N400 has been shown to index semantic integration process (Thierry and Wu, 2007).

auditory one, they provided responses 109ms more rapidly. Furthermore, when the distribution of the N400 effect was compared in the two modalities it was observed that "written words […] tended to elicit a slightly larger N400 effect over the right hemisphere, whereas spoken words produced a more bilateral symmetrical response" (Anderson and Holcomb, 1995:178). Moreover, Holcomb and Neville (1990:302) reported that "the ERPs to related and unrelated words started to differentiate between 200ms and 290ms in the auditory modality, whereas the analogous visual waves did not differ until 300ms and 360ms." The researchers interpreted the findings as supporting the Marslen-Wilson hypothesis, which states that spoken word recognition (in context) can take place before all of the acoustic information is available for processing (Marslen-Wilson, 1987). Based on the above, Holcomb and Neville (1990) drew the conclusion that even though there might be an overlap between the priming processes seen in visual and auditory modalities, these are not identical.

The findings demonstrated by Holcomb and Neville (1990) were interpreted differently by Anderson and Holcomb (1995). According to them, it is likely that the earlier onset of the N400 for spoken words may indicate that the semantic information becomes available earlier on in the auditory modality than in the visual one. To advance this alternative explanation and to address a methodological constraint of Holcomb's and Neville (1990) study[63], Anderson and Holcomb (1995) conducted another investigation, which specifically focused on the time course of semantic processing within the two modalities. The researchers examined auditory and visual semantic priming across three SOAs (0ms, 200ms, and 800ms) and demonstrated that the semantic priming effect (behavioural and electrophysiological) in the auditory experiment was again greater than

[63] Holcomb and Neville (1990) used an SOA of 1,150ms. Such a long interval between the presentation of prime and target could have resulted in the use of different strategies for processing written and spoken words (Anderson and Holcomb, 1995).

in the visual experiment. Furthermore, it was shown that in the auditory experiment, the priming effect correlated positively with the SOA, i.e. it was greater with longer SOAs (0SOA - 18ms; 200SOA – 57; 800SOA – 142ms), whereas in the visual experiment, the priming decreased with extended SOAs (0SOA – 53ms; 200SOA – 32ms; 800SOA – 19ms) (Figure 14). Also, there was a different pattern of the ERP effect in the two modalities. In the auditory modality, the N400 priming effect was largest at the longest SOA (800ms), whereas in the visual one it did not differ significantly across the three SOAs. The researchers, however, observed a later significant ERP priming effect (550ms – 800ms) in the 0ms experimental condition.

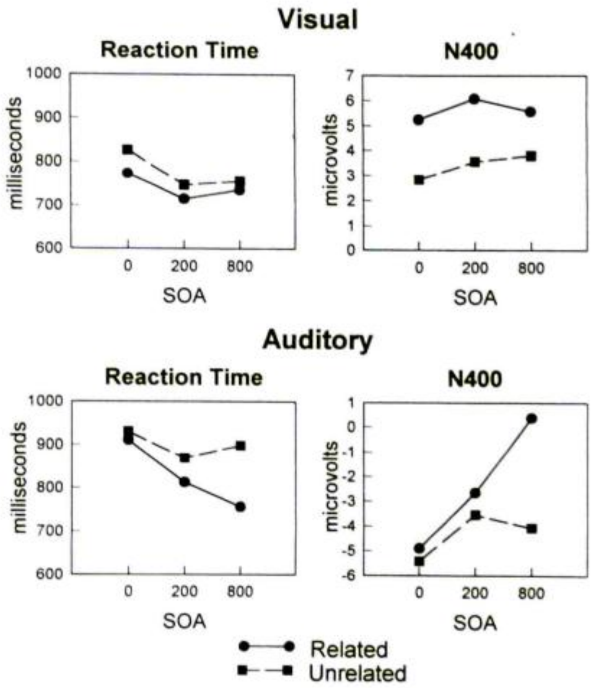


Figure 14. RT and N400 priming effects (Anderson and Holcomb, 1995:189).

Anderson and Holcomb (1995) concluded that the information from the targets may become available at different rates in the two modalities. It may also be prone to the attentional demands, i.e. interference when stimuli are presented simultaneously or when a target is shown/played before the presentation of the prime has been completed. Therefore, to explore the priming effect in the visual and auditory modalities, two versions of the priming task[64] were designed for this study. Different SOAs were adapted in the visual and auditory tasks, which was motivated by the need to measure automatic language processing. Furthermore, since currently there are no studies with Chinese-English bilinguals that compare the performance on a cross-language priming task in these two modalities, it was difficult to predict the data that would be obtained. It was assumed that a difference in priming performance between the visual and auditory condition would be observed, but it was not possible to point to the directionality of it. Nevertheless, since in Chinese, the character's graphic form disambiguates the meaning, it was possible that visually presented words might be recognized more quickly and therefore there would be an observable difference in the priming effects between the two modalities.

2.6 Semantic judgement task

Pavlenko (2009:128) stated that "reaction-based tasks, developed for the study of language processing, are well-suited for examining the strength of interlingual connections, but do not offer us any means to examine the contents of linguistic categories and thus to determine the degree to which they are actually shared." Consequently, in order to address the degree of the semantic overlap between the two languages (Chinese and English) a semantic judgment task[65] was chosen in this study. The task was administered to the bilingual and monolingual participants and the results analysed with the use of the multidimensional scaling technique. This technique is seen by many researchers as very useful. It is based on the notion that "each individual has an integral cognitive representation of the semantic structure of terms [and] the meaning of each term is defined by its location relative to all the other terms" (Moore et al., 1999:532). This technique is "sensitive to underlying regularities in a set of data"

[64] The design and procedure of each of the experiments is described in detail in subsections 3.2.1 and 3.2.2 of chapter three.

[65] A detailed description of the task that was used in this project is given in section 3.4 of chapter three.

(Herrmann and Raybeck, 1981:195) and it allows for the investigation of the structure of semantic domains (Romney et al., 1997).

A semantic domain can be understood as an organized set of words that refer to a single conceptual category, such as kinship terms, colour terms, emotion terms, or names of animals, whereas the structure of a semantic domain may be described as the arrangement of the terms relative to each other represented in Euclidean space[66]. The structure of a semantic domain is derived from a judged-similarity task[67], which commonly takes two forms. Either the participants are presented with pairs of words and are requested to indicate on a scale (e.g. 1 referring to most dissimilar to 7 standing for most similar) how similar they are, or alternatively they are shown three words, triplets, and are asked to point to the word that is least similar to the other two. Once, the stimuli word lists of a given semantic domain are ranked (how similar or dissimilar they are), multidimensional scaling analysis allows for a production of a spatial representation of the semantic relationship between terms, in the form of a conceptual map (Herrmann and Raybeck, 1981). Examples of conceptual maps of the semantic domain of colours, from a study conducted by Moore and colleagues (2000), are presented in Figure 15. The map is then further interpreted accepting the fact that terms that are judged more similar are closer to each other than terms that are judged less similar (Romney et al., 1997). For instance, it can be seen from the maps in Figure 15 that colours such as orange and yellow were seen by the participants as more similar to one another as compared to, for example orange and blue, that are much further apart, judged by the participants as less similar.

[66] In geometry, Euclidean space is a two- or three-dimensional space in which the axioms and postulates of Euclidean geometry apply (Encyclopaedia Britannica, on-line). In this project, a two dimensional space is used; however, three and four dimensional spaces are investigated too.
[67] A judged-similarity task is referred to as semantic judgment task in this study.

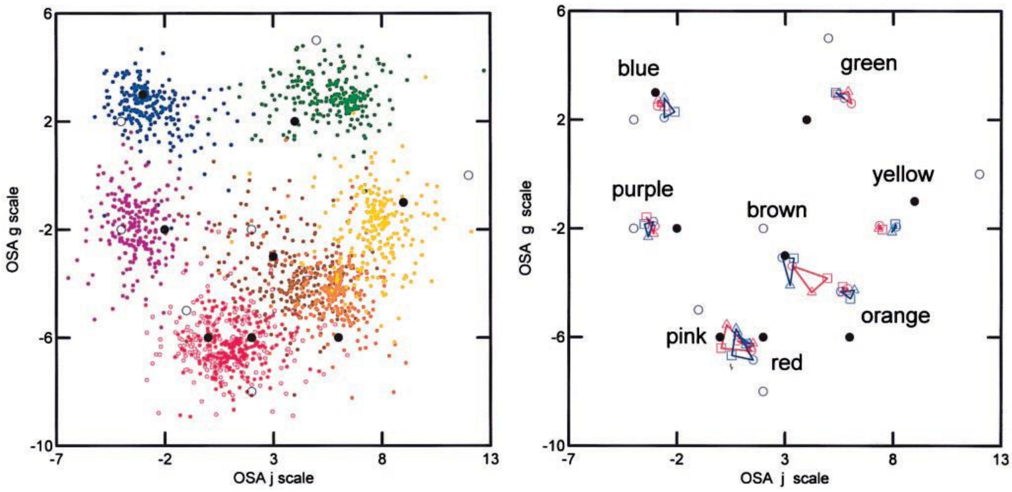
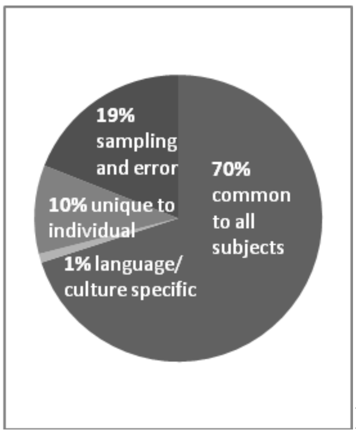
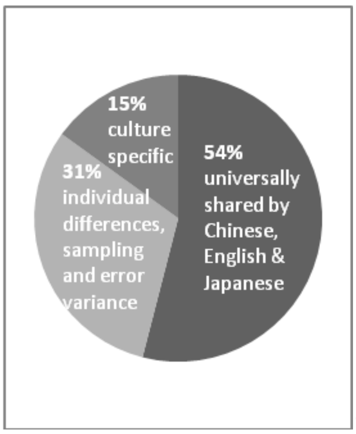


Figure 15. Examples of conceptual maps (Moore et al., 2000:5009).

Previous studies, which employed the multidimensional scaling technique to investigate the semantic domains (e.g. Herrmann and Raybeck, 1981; Moore et al., 2000a; Moore et al., 1999; Raybeck and Herrmann, 1990; Romney et al., 1997), demonstrated that to large extent semantic structures are similar for different languages and cultures. Moore et al. (2000b; 1999) and Romney et al. (1997) compared the semantic domains of colours and emotions and demonstrated that there are universally shared similarities among the way speakers of English, Chinese and Japanese see the interrelationship among the meaning of colour (Figure 16A) and emotion terms (Figure 16B and 16C). That is, the researchers reported 70% shared cultural knowledge for colour terms, 59% and 66% for the emotion terms. Moreover, the culture (language) specific knowledge accounted for 1% for the colour terms, 15% and 6% for the emotion terms.

A 

B 

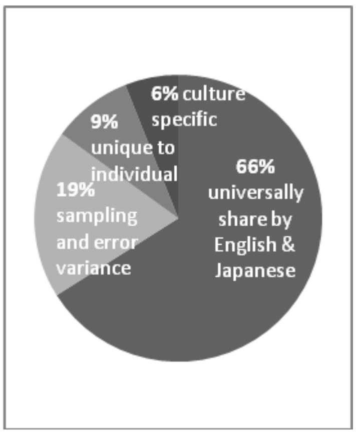
C 

Figure 16. Pie charts representing contributions to semantic structure from four sources: the common share model, culture-specific model, individual component and error variance; Figure A – Romney et al. (1997), Figure B - Moore et al. (1999) and Figure C – Moore et al. (2000).

2.6.1 Semantic domain of animals

In the current study, the semantic domain of animals was investigated. The domain of animals was selected as the exemplars are concrete entities that have well defined physical characteristics, such as: size, shape, or colour. Furthermore, as indicated by Romney and Moore (1998:316), "animals were also always present in the environment in which humans evolved so that the evolution of visual mechanisms for their detection and characterisation can be assumed." In this research, 12 animal terms (*ant, cow, elephant, panda, camel, spider, bee, lion, monkey, butterfly, rabbit, tiger*) were selected and combined into 66 pairs, so that each word was compared with every other on a 6 point Likert scale[68]. The semantic domain of the animals was previously investigated by e.g. Romney and associates (1995) and Herrmann and Raybeck (1981). In Romney et al.'s work, the participants were asked to compare 21 animal terms (*antelope, beaver, camel, cat, chimpanzee, chipmunk, cow, deer, dog, elephant, giraffe, goat, gorilla, horse, lion, monkey, rabbit, rat, sheep, tiger, zebra*) on a 20 point scale[69]; whereas, Herrmann and Raybeck asked their participants to compare 12 animal terms (*sheep, goat, cow, horse, deer, bear, lion, pig, dog, cat, mouse, rabbit*) using a four point scale. Examples of the conceptual maps produced by Romney et al. (1995) and Herrmann and Raybeck (1981) are given in Figures 17 and 18 below.

[68] The choice of a 6 point scale in this study was motivated by two considerations, i.e. removal of the mid-point (e.g. in a 5 point scale) and provision of a scale that is broad enough to offer a range of judgements, but one that is at the same time manageable. Herrmann and Raybeck (1981) used a 4 point scale that was considered too narrow; whereas Romney's et al. (1995) 20 point scale was viewed by this researcher as too complex.

[69] The paired comparison was one of the tasks that Romney et al. (1995) used. The researchers also administered a triadic comparison task. The map presented in Figure 1 was produced on the basis of the ratings from both tasks.

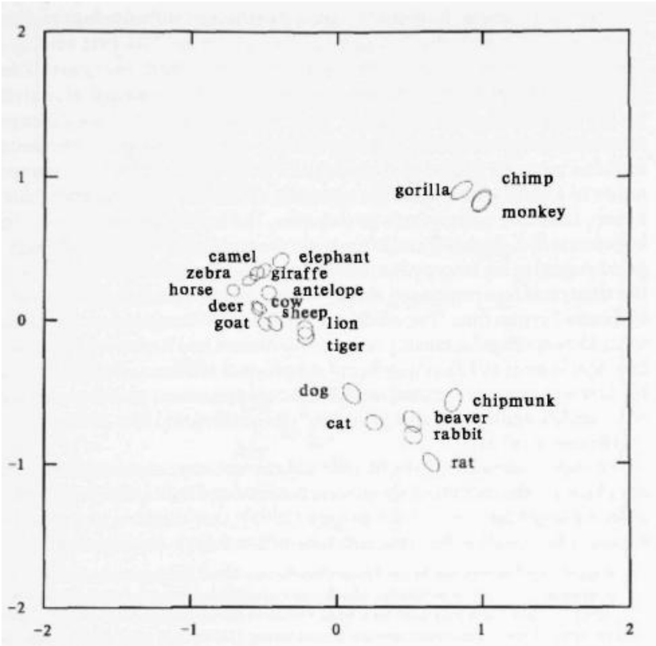


Figure 17. Semantic structure of 21 English animal terms (Romney et al. 1995:278).

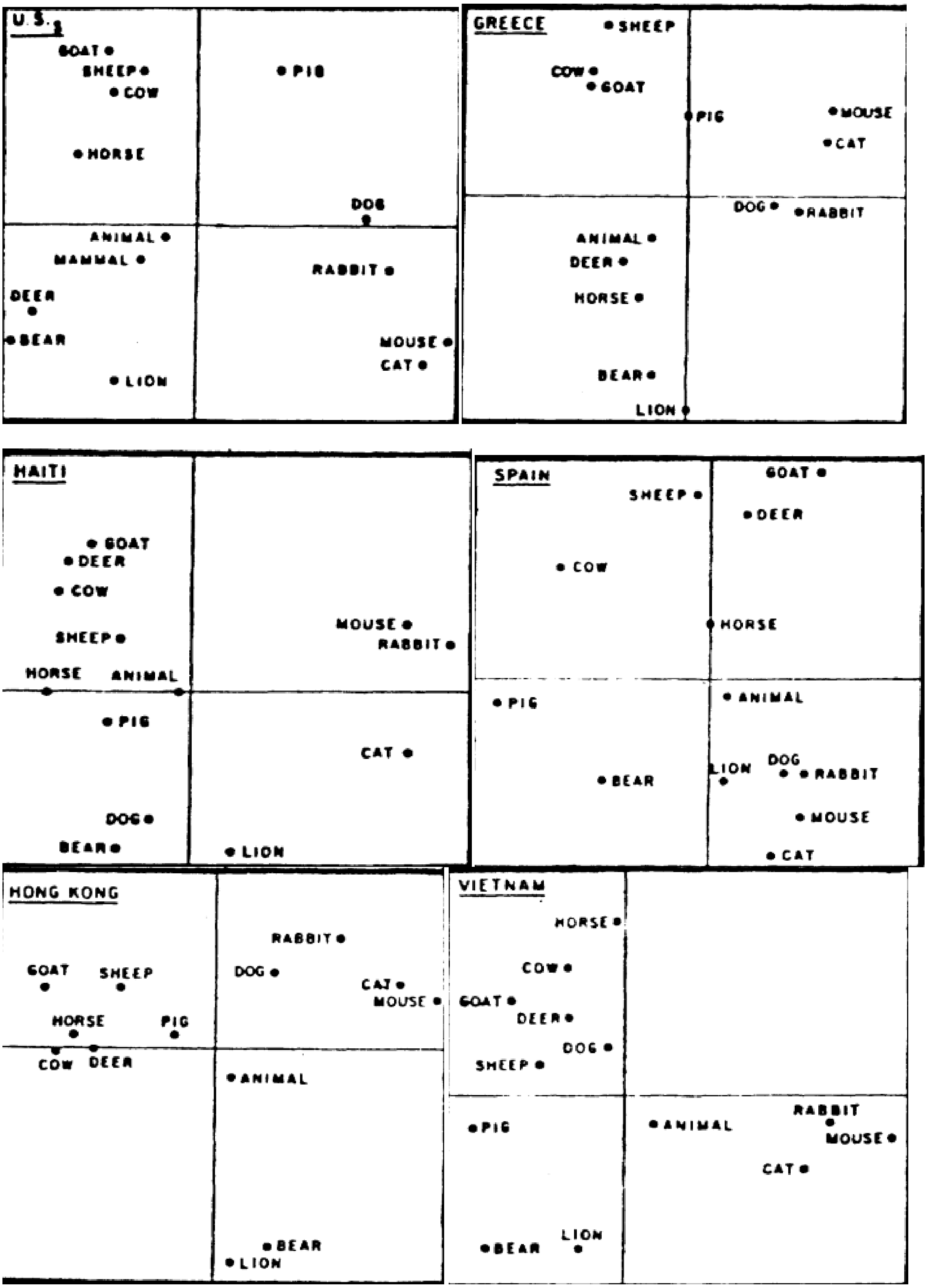


Figure 18. Semantic structure of 12 animal terms across six cultures: American, Greek, Haitian, Spanish, Hong Kongnese, Vietnamese (Herrmann & Raybeck, 1981:199).

Figure 17 clearly illustrates similarities between the animal terms in terms of distance. That is, terms such as *gorilla, chimp,* and *monkey* are closer to each other as compared to e.g. *rat* and *elephant*, thus it is clearly visible that more similar animal terms cluster and overlap. A similar pattern can also be observed on the individual maps included in Figure 18; however, when the distribution of animal terms across the maps from different cultures is compared, it results in considerable variation. Herrmann and Raybeck (1981:203) noted that “the positions of terms in many cases do not agree across all cultures in our study, and these discrepancies may very well reflect salient cultural differences”. This can be seen as evidence that members of various cultures, e.g. Americans, Greeks and Haitians conceptualise animals in a slightly different way (as seen on the conceptual maps). Therefore, it is also worth examining if bilinguals who speak two languages on a daily basis and who often function in two different cultures perceive/conceptualise animals in the same way in both of their languages or not. More specifically, do bilinguals use the same or a similar set of judgements to classify animals?

Drawing on the design of the two studies presented above, i.e. Romney et al. (1995) and Herrmann and Raybeck (1981), a semantic judgement task was constructed for this study, details of which are given in Chapter 3, Section 3.4. The investigation of the semantic domain of animals allowed for addressing the notion of the degree of semantic overlap between Chinese and English languages in bilingual speakers as well as for comparing bilingual and monolingual semantic structures.

2.7 Aims and hypotheses

The aim of the present project is fourfold. First, this study is intended to shed more light on the way meanings of translation equivalents in Chinese-English bilinguals are represented in memory. Second, it has the goal of investigating the aspect of bilingual language processing and also widening the scope of the findings by focusing on both auditory and visual modalities of word recognition. Finally, this project aims to provide a greater understanding of the degree of the semantic overlap for the chosen pair of languages with the use of a technique that has not been extensively exploited in the field of psycholinguistics, i.e. the multidimensional scaling technique.

The above mentioned aims of the study are formulated into four hypotheses, two of which are derived from the theoretical assumptions of the RHM (Kroll and Stewart, 1994). First, evidence was gathered to assess the notion of shared versus separate semantic representations for Chinese-English pair of languages. It was assumed that if a priming effect is observed in a cross-language condition, it can be interpreted as providing support for the shared conceptual representations in the bilingual memory of Chinese-English speakers. Second, the representational account, outlined by the RHM is under scrutiny. Regarding this, it is hypothesised that if a priming asymmetry effect is detected between the two translation directions (from L1 to L2 and from L2 to L1), it will support the notion of different strengths of lexical connections between lexical stores (L1 and L2) and the conceptual store (C). Next, the visual and auditory presentation modalities are investigated. It is expected that there is a difference in reaction times between the two modalities; however, no prediction about the directionality of the effect has been made. Finally, the degree of semantic overlap is examined with the use of the multidimensional scaling technique.

To sum up, the main four hypotheses investigated in this project are:

1. The priming effect will be observable in an implicit conceptual memory task, i.e. in an animacy decision task, if the information stored at the conceptual level in the bilingual Chinese-English mental lexicon is shared.
2. The priming asymmetry effect will be observable between two language directions (from L1 to L2 and from L2 to L1), i.e. it will be greater in magnitude

for the L1 to L2 language direction compared with the L2 to L1 language direction if the strength of connection differs, as outlined by the RHM.

3. There will be a difference between the priming effect for words presented in the visual and auditory modalities, which would demonstrate that these processes are not identical and that the processing of words is modality-dependent.
4. The spatial representation of the semantic domain of animals, i.e. the distribution of terms on the conceptual map, will be similar[70] for Chinese and English words, if the conceptual information is shared between the two languages in Chinese-English bilinguals.

To explain how each of the four hypotheses was investigated, a detailed explanation of the research tools, employed in this study, will be given in the research methods chapter that follows.

[70] Similarity and/or difference derived from a semantic judgement task are presented on a conceptual map as distance. It is implied here that the distance between the bilingual English and the bilingual Chinese semantic structure will be small, which will in turn point to the fact that the bilingual participants conceptualised the semantic domain of animals similarly in their two languages.

CHAPTER THREE

RESEARCH METHODS

This chapter presents the methods that were employed to investigate the representation and processing of the mental lexicon in Chinese-English bilinguals. First of all, the groups of participants recruited for this project are described. Then, the focus is drawn towards the biographical questionnaires, which were administered to select the groups of bilingual and monolingual participants. Next, the discussion centres around the main research tool, i.e. the masked priming paradigm and the design of the tasks as well as the experimental procedure are delineated. This is followed by a description of the semantic judgement task, which was used to investigate the degree of semantic overlap between Chinese and English language in bilinguals. Finally, the piloting stage, which allowed for the adjustment of the research tools, is presented and a brief consideration of several ethical issues is given.

3.1 Participants

Three groups of participants were recruited for this project: a bilingual Chinese-English group, a monolingual English group, and a Chinese monolingual group. The participants were recruited in three cities: Hong Kong, Beijing, and London. Each group of the participants is described separately in the forthcoming sections below.

3.1.1 Bilingual participants

A group of 126 bilingual Mandarin Chinese-English participants was recruited to take part in the priming and the semantic judgement tasks. The size of this sample was estimated based on the number of independent variables controlled for in the priming experiment. The priming effect was measured in terms of the variance in reaction times and error rates and it was evaluated with the use of repeated measures ANOVA, with effects within subjects (prime relatedness) and between subjects (language group, modality). The sample size for the priming task was calculated a priori with the use of the G*Power program considering a medium effect size of 0.25 and statistical power of 0.9. The sample size was estimated to be 100. However, in order to assure homogeneity of the bilingual sample, a group of 126 participants was initially recruited, which allowed for exclusion of those participants who did not meet the selection criteria, i.e. participants between the age of 18 to 25, right-handed and dominant in Mandarin Chinese.

The participants were recruited from two universities in Hong Kong: the University of Hong Kong (HKU) (99) and the Chinese University of Hong Kong (CUHK) (27). The HKU was selected as a primary site for the recruitment of participants due to the fact that English is the medium of instruction at this university; hence, a great majority of the Chinese students are highly proficient in English. The CUHK was chosen due to the fact that it offers courses that attract large numbers of Mandarin Chinese speakers. The recruitment of the participants was carried out in several ways, i.e. via posters and fliers that were displayed on notice boards on campus and in the halls of residence, Internet adverts posted on the webpage of the Chinese Students and Scholars Association at the HKU, visits to Cantonese classes conducted for Mandarin speakers, and via word of mouth. The whole process took six months, starting in October 2011 and being completed by the end of March 2012.

All participants recruited for this project were enrolled on undergraduate or postgraduate courses. The age range varied from 18 to 29 (55 participants were between 18 and 21; 69 were between 22 and 25; and 2 were between 26 and 29); however, data from only those participants who were above 18 and under 25 years of age, was included in the final analysis. In order to measure reaction times (RT) in the priming task, the age needed to be controlled for, because as people get older, their RT change and that may skew the data.

It has been recently demonstrated that the priming asymmetry effect (described in Section 2.5.3) seems to be cancelled out by a relative bilingual balance (Wang, 2013). However, the phenomenon of balance bilingualism is less prevalent than dominant bilingualism (Grosjean, 1998). This is certainly true for Chinese speakers of English who rarely are brought up in two languages simultaneously from a very young age. In most cases, English is introduced at early stages of formal schooling (this is also confirmed by the L2 AOA data collected in this study). To ensure homogeneity of the bilingual sample, the decision was made to focus on those participants that were dominant in Mandarin Chinese taking also into account the environment in which data collection was performed i.e. Hong Kong. In this study, language dominance was understood as “a the relationship between the competencies in the two languages of the bilingual” (Treffers-Daller, 2011:148) and has been subsumed by the definition of bilingualism, coined by Grosjean (1998), which was also the operational definition of this investigation. In order to address the notion of language dominance, the participants were requested to report the language in which their primary and secondary education was conducted; the age and context of their L2 (English) acquisition; their subjective opinion on whether they considered themselves to be bilingual and whether they thought that one of their languages was more dominant than the other. Exactly 97% of the participants said that they received education at a primary level in Chinese, whereas the secondary school education was conducted for half of the participants in Chinese and the other half in English. Also, 97% of all participants pointed that they learned English at school in a formal setting, with the remaining 3% indicating that they received informal language instruction at home and/or formal teaching at tutorial/educational centres. Additionally, 75% of the participants described themselves as bilingual; 81% of all participants indicated that they were not equally proficient in Chinese and English; and that their Chinese was more dominant. Even though most of the given answers pointed to the Chinese language dominance for majority of the participants, there were some inconsistencies in the provided answers. Therefore, to explore the language dominance in more detail and to include only those participants that were dominant in Mandarin Chinese a factor analysis (FA) was performed on four sets of answers from the questionnaire regarding: (1) context of English language use, (2) context of Chinese language use, (3) language preference, and (4) English language proficiency. Based on the FA, data from 10 participants was discarded and those participants were excluded from the study. The details of the factor analysis are attached in Appendix 14. Here, language preference characteristics of the final set of the bilingual participants are given in Table 9. A quick look at the table is sufficient to notice that the selected group of bilinguals was dominant in Mandarin Chinese. A great majority of participants indicated having a preference for Chinese language when it came to thinking (96%), doing simple Maths (97%) and understanding humour (97%). Slightly lower percentages were noted for watching TV (82%) and reading books (78%), which could be related to the trilingual environment (Cantonese, Mandarin, English) of Hong Kong, where the data was collected.

	Chinese	English
preference	95%	5%
use	97%	3%
think in	96%	4%
do simple Maths	97%	3%
watch TV	82%	18%
read	78%	22%
understand humour	97%	3%

Table 9. Language preference characteristics of the final set of bilingual participants.

All in all, from the initial group of 126 bilingual participants that were recruited for this project, data from 96 of them was included in the final analysis of variance. The background characteristics of the final set of bilingual participants are given in Table 10 below. Approximately half of all participants were between 18 and 21 years old and were enrolled on undergraduate courses, whilst the other half were between 22 and 25 years old and following postgraduate programmes. The majority of the participants received their primary school education in Chinese, whereas secondary school training was conducted for half of the participants in English. The mean age of L2 acquisition was equal to 9 years of age, which is equivalent to Grade 3 at a primary school. This is the stage at which most commonly a foreign language, in most cases English, is introduced. This is also reflected in the answer provided to the question regarding context of L2 acquisition. 99% of participants indicated that they learnt English at school. Finally, most participants (73%) indicated that they had spent less than a year in Hong Kong[71].

[71] Data collection commenced in October 2011 right after the beginning of a new academic year.

number of participants	96
age	46% 18 – 21 years 54% 22 – 25 years
level of education	48% undergraduate 52% postgraduate
primary school education	99% in Chinese 1% in English
secondary school education	53% in Chinese 47% in English
age began L2	M = 9.13 years (SD = 2.67)
context of L2 acquisition	99% at school 1% other
length of residency in HK	73% < 1 year 12% 1 – 2 years 2% 3 – 4 years 4% 5 – 6 years 9 % > 6 years

Table 10. Background characteristics of the final set of the bilingual participants.

English language proficiency[72] was evaluated on the basis of a self-rating scale and participants' ratings are presented in Table 11 below. The self-assessment of language proficiency has been under a lot of critique (e.g. Hulstijn, 2012; MacIntyre et al., 1997) For instance, MacIntyre and colleagues (1997:266) demonstrated that "anxious students tended to underestimate their competence relative to less anxious students, who tended to overestimate their competence". Despite this criticism, this researcher made a decision to use a self-rating scale following Lim's and associates (2008:393) statement that "there is a growing body of research that shows that self-assessment of proficiency are valid and reliable measures of language skills, and are correlated highly with ratings by experienced judges and standardized test".

[72] It was pointed out that language proficiency may be a potential confounding variable. Therefore, additional analysis on RTs was conducted with language proficiency as a covariate. The outcome, however, was not statistically significant. The results of this analysis are included in Appendix 17.

	listening	speaking	reading	writing	use of grammar
English	2.92 (0.556)	2.66 (0.577)	3.12 (0.548)	2.73 (0.607)	2.98 (0.680)

Table 11. Means based on participants self-rating of the main English language skills on a 4 point Likert scale (1 - not well at all; 2 - not so well; 3 - pretty well; 4 - very well). Standard deviations are included in the parenthesis. The mode for all skills was 3/pretty well; whereas, the range was equal 2 (2 – 4) for listening, reading (receptive skills), and grammar; and 3 (1 – 4) for speaking and writing (productive skills).

The selection criteria were set strict in order to ensure uniformity of the sample and comparability of the data. Data from only those participants who were between the ages of 18 to 25; who were right handed; who were dominant in Mandarin Chinese rather than English was taken into account.

3.1.2 Monolingual participants

Groups of 23 monolingual English and 16 monolingual Chinese participants were recruited as controls for the semantic judgement task (section 3.4 of this chapter). The size of the monolingual sample was calculated based on the numbers of bilingual informants needed to participate in the semantic judgement task. The monolingual participants were native speakers of English or Chinese between the ages of 18 and 25. The monolingual English speakers were approached and recruited at King’s College London, whereas the Chinese monolingual participants were recruited at the China University of Geosciences, Beijing. Since the detailed characteristic of both groups differs slightly, they are described separately below.

3.1.2.1 Monolingual English participants

The 23 English speaking participants were recruited remotely[73] via a circular email at King’s College London. The participants were between 18 to 25 years old (18 of them were between 18 and 21 and five were between 22 and 25 years old). The gender

[73] It was not possible for the researcher to meet the participants in person due to the location constraints, i.e. the recruitment of the participants in Hong Kong. The participants in London were given all necessary information via email as well as online access to tasks, which they could complete at any convenient time.

distribution was slightly skewed; 15 of the English participants were female and eight were male. All but two were enrolled on undergraduate courses; the remaining two were postgraduates. Moreover, all said that they had received both their primary and secondary education in English. Also, most of them (18) indicated being born in the United Kingdom, with the other five students reporting having been born in: South Africa, the USA, Singapore, Germany, and Malaysia. The data from the students who were born in the last three countries was excluded from the final data analysis based on the fact that English is not the main official language in those nations. The length of residency in the UK varied for the participants from less than five years (two) to over 19 years (18).

Almost 35% of the participants indicated that they could speak a foreign/another language (4 participants – French, 3 – Spanish, 1 – British Sign Language), but when they were asked to evaluate the fluency and frequency of use, they reported this was at a basic level on rare occasions, such as during holidays abroad. Hence, a decision was made to retain the data from those students for the final analysis, in particular because it can be very difficult to find 'true' monolingual speakers who are educated to a university level.

3.1.2.2 Monolingual Chinese participants

Similarly to the participants in London, the participants in Beijing (16) were recruited remotely via recruitment emails. Two of them indicated that they were 17 years old, which was considered too young and hence the data from those students was discarded from the final analysis. The remaining 14 reported being between 18 and 25 years old. The gender distribution was also skewed for this sample, however, in the opposite direction to the English monolingual group of participants; more male students (10) participated than female (six). This difference might be related to the nature of the university that the sample was drawn from, i.e. a University of Geosciences. All the students were following undergraduate courses. Furthermore, all of the participants were born in Mainland China, had received both their primary and secondary education in Mandarin Chinese, and indicated that they had lived in China for more than 15 years. Finally, about half of the participants said that they were able to speak one another language, i.e. English. Nonetheless, similarly to the English participants, they rated their ability to use the language as basic and the frequency as rare or sporadic. Therefore for the purpose of this study they were treated as monolingual.

3.2 Design of the questionnaires and procedure

In order to select the groups of participants for this project, three biographical questionnaires were designed: bilingual, English monolingual and Chinese monolingual. The aims and the content of each of these are described separately below.

3.2.1 Bilingual questionnaire

Grosjean (1998:135) suggested that papers in experimental psycholinguistics should report the following information about groups of participants: biographical data (age, sex, education level); language history (age and context of language acquisition); language stability (developing language skills); function of languages (purpose and context of language use); language proficiency (proficiency in four language skills); and language mode (amount of time spent in the monolingual mode and in the bilingual one). This is because this type of information not only allows for describing types of bilinguals (e.g. adult bilinguals, child bilinguals and second language learners), but it also makes a comparison of samples from different studies easier. Hence, a majority of the above mentioned elements were incorporated into the questionnaire administered to the bilingual participants in this study. The data collected from the questionnaires, in turn, helped to identify those participants that met the selection criteria for inclusion in the subsequent tasks.

The bilingual questionnaire (Appendix 2) comprised three parts: personal details, a language ability scale, and a language preference section. All three parts were aimed at establishing the type of bilingualism represented, the language history, English language ability and language preference. The first part, the personal details, included seventeen questions, which focused on collecting information about age, gender, the participant's country of origin, age and the context of L2 acquisition, context of language use, and their view on whether they consider themselves to be balanced or dominant bilinguals. The second part, the language ability scale, had six questions, which were related to the four main language skills (speaking, reading, writing, and listening), and the use of English grammar. The answers were provided in form of a four point Likert scale (i.e. not well at all/not so well/pretty well/very well) and the participants were requested to indicate the option which applied to them most. The third part, the language preference section, comprised seven questions, which were aimed at investigating participants' preference regarding Chinese (L1) and/or English (L2) language use. Once again, choices of response were provided and the participants had to indicate their preference by putting a tick in a box next to the answer that applied to them most.

The bilingual questionnaire was designed based on the information adapted from a questionnaire that was used by Kharkhurin (2005) in his doctoral project. This scholar used his questionnaire to assess the participants' language proficiency and their cross-cultural experience. However, the questionnaire which was used in this project was modified in a number of ways. First of all, some of the questions originally included in Kharkhurin's project were eliminated, because they were considered too personal or inappropriate. For example, a question regarding language in which one dreams was excluded. Secondly, some other questions were altered. For instance, the question regarding understanding English language was split into two separate ones, i.e. into understanding spoken English and understanding written English. Furthermore, the wording of several other questions was simplified, e.g. the original question “In which language do you prefer to make mental arithmetic operations?” was changed to “In which language do you most often carry out easy mathematical calculations, e.g. 2+2=?” Additionally, the wording of the scale used in the language self-assessment part was modified. That is, the originally used words “not at all/fair/well/very well” were substituted with “not well at all/not so well/pretty well/very well”. Finally, the overall layout, presentation, and order of the questions were changed. The majority of the questions were fixed-choice and the participants were asked to tick a box next to the answer that applied to them most. All these measures were introduced to diminish ambiguity, ensure easy comprehension of the questions and to minimize the amount of time needed to fill in the questionnaire.

All bilingual participants were asked to fill in a contact details form (Appendix 4A and 4B)[74] and the questionnaire before taking part in the main experimental tasks. The participants were tested individually. They were seated at a table, in a comfortable position. The questionnaire was presented in electronic format[75] and the participants were requested to click on the boxes provided next to the answers or to type their answers in English. On average, it took them from two to three minutes to fill in the questionnaire.

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[74] The original English contact details form was translated into Mandarin Chinese by a native Mandarin speaker. The bilingual speakers and the English monolingual speakers provided their details using the English form (4A), whereas the Chinese monolingual speakers used the Chinese one (4B).

[75] All electronic tools were designed and presented to the participants with the use of the LimeService, the official LimeSurvey hosting platform.

3.2.2 Monolingual questionnaire

Two versions of the monolingual questionnaire, i.e. English and Chinese (Appendix 3A and 3B)[76] were designed to select monolingual English and Chinese participants, who were recruited as controls for the semantic judgement task. This questionnaire comprised eight questions about the participants' age, gender, country of origin, language in which they were educated, their ability to speak foreign languages, as well as their subjective judgment regarding their fluency in any foreign language, their frequency of use and the context of its use of the foreign language. This information was collected to establish whether the participants were native speakers of English or Chinese and if they were monolingual. The procedure of carrying out the task was identical to the one employed for bilingual participants. The only difference was that while the English participants typed their answers in English, the Chinese participants gave their answers in simplified Mandarin Chinese.

3.3 Design of the priming tasks and procedure

In order to address the first three hypotheses of this project, i.e. the shared versus separate semantic representations, the representational account outlined by the RHM, and the visual and auditory modalities of word recognition, an animacy decision task was selected. The task was presented in the form of a masked priming paradigm. During the task, the participants were requested to make a living – non-living decision ('is this a living or non-living thing?') about words displayed on the computer screen or heard via a set of headphones. This type of task represents a form of implicit memory task and it allows for measuring the conceptual level of information (Zeelenberg and Pecher, 2003). It was reported before that data obtained from an LDT is often conflicting (Gollan and Kroll, 2001). Hence, in this study, a decision was made to employ a decision task in

[76] The original English questionnaire was translated into Mandarin Chinese by a native Mandarin speaker.

which participants would need to access the conceptual store and retrieve semantic information in order to indicate whether a given target is a living or non-living exemplar. The choice of the stimuli, the design and the procedure of the priming animacy decision task is presented in the sections below.

3.3.1 Stimuli and design

The materials for the priming experiment comprised 140 pairs of words in Chinese and English, including 60 related pairs (translation equivalents in Chinese and English), 60 unrelated pairs (words in L1 and L2 that did not share meaning), and 20 fillers. A complete list of the stimuli is included in Appendix 5. Forster (2000) expressed his concern over the selection of stimuli for word recognition experiments that are based on a comparison of two matched sets of words. He suggested that the experimenters may introduce bias by hand picking materials appropriate for a given experiment rather than based on a set of specific selection criteria. Furthermore, this author stressed the importance of choosing items at random by indicating that "the experimenters could potentially produce spurious effect sizes ranging from 16 to 38ms." Therefore, great caution over the selection of stimuli was exercised in this study and initially a list of 240 word pairs was created, from which critical experimental items (140) were picked at random.

Some of the stimuli were chosen from lists used in studies carried out by Azuma and Van Orden (1997), Lin and Ahrens (2000, 2005; 2010), Jiang (2002, 2004), and Zeelenberg and Pecher (2003), whereas the great majority of the words were selected by this researcher following strict selection criteria. The chosen words were concrete nouns with one dominant meaning in both languages. Half of the pairs of words represented living exemplars and half non-living exemplars. The living ones represented the following categories: people, professions, plants and animals; whereas, the non-living words were: examples of things, objects, musical instruments, pieces of clothing, buildings, and places. Previous studies (e.g. Zeelenberg and Pecher, 2003 or Li et al., 2009) which employed the animacy decision task also included the names of fruit, vegetable and body parts as living exemplars. However, these types of words were not selected as stimuli in this project as they might be viewed as ambiguous. For example, words such as *peach* or *stomach* are not unanimously understood as living exemplars by either Chinese or English speakers.

The majority of the words were initially chosen in English and translated into Chinese by this researcher and each entry was checked with the use of an on-line English-Chinese dictionary (http://www.nciku.com). Next, the same procedure was repeated but in the reverse language direction, from Chinese to English. This time the checking of the entries was carried out with the help of The Pocket Oxford Chinese Dictionary (1999). Once, a complete list of stimuli was prepared, it was verified by two bilingual, Mandarin Chinese-English, speakers and all necessary adjustments were introduced, e.g. some words were eliminated or exchanged with other translation equivalents. For instance, words such as: *miányáng* (绵羊), *shānyáng* (山羊), and *gāoyáng* (羔羊), meaning respectively 'sheep', 'goat', and 'lamb' in English were removed from the related list of words as they can be easily confused by Chinese speakers, because of the character *yáng* (羊) meaning 'sheep' that all of these contain.

All of the Chinese words were simplified[77] two-character (bisyllabic) lexical units, e.g. *mǎyǐ* (蚂蚁) meaning 'ant' or *qìqiú* (气球) meaning 'balloon'. Two-character words were chosen due to the fact that the same stimuli were used in both the visual and auditory format of the priming task (subsection 3.3.2 of this chapter). That is, since the

[77] Simplified Chinese characters are standardized Chinese characters used in Mainland China.

Chinese language is characterised by a high degree of homophony, it might have been difficult for the participants to recognize single character (monosyllabic) words without context (Tan et al., 2000). Hence, to diminish ambiguity and allow better comprehension in the auditory priming task, two-character Chinese words were chosen.

The next step in the stimuli list preparation involved providing frequency counts, the number of letters for the English words and the number of strokes for the Chinese characters. The English words were from three to seven letters long (M = 5; SD = 1.1), whereas the Chinese characters varied in complexity from five to 25 strokes (M = 15; SD = 4.4) (detailed letter and stroke counts for all stimuli are given in Appendix 6). Owing to the difference in scripts, it was difficult to compare the two languages in terms of length, however, care was taken to ensure that all the Chinese words were bisyllabic and all the English ones were either monosyllabic or bisyllabic. The printed word frequency for the Chinese words could not have been established as the majority of the frequency counts available are provided for single character words, which do not reflect the frequency of bisyllabic characters used in this project[78]. Moreover, since the age of acquisition (AoA) data were not available for either of the languages, a relatively novel approach was employed to make sure that all the stimuli were commonly used nouns, familiar to the participants. That is, the list of stimuli was checked against a Chinese-English children's dictionary (Amery and Cartwright, 2006) and words which did not exist as entries were removed from the list. Furthermore, careful attention was paid to make sure that the selected translation equivalents in Chinese and English did not share cognate status. For instance, words such as *mángguǒ* (芒果) meaning 'mango' in English or *shāfā* (沙发), which stands for 'sofa' in English, were eliminated during the selection stage.

[78] Previous studies, e.g. Zeelenberg and Pecher, 2003 and Li et al., 2009, used single character Chinese words as stimuli; hence it was possible for them to provide mean frequency counts.

All in all, the selected stimuli were used to create two lists of counterbalanced items with the target words either being preceded by related (translation equivalents) or unrelated primes (words that do not share meaning). The types and distribution of the stimuli words used in the priming experiment is presented in Table 12.

120 targets & primes			
30 living related exemplars		**30 living unrelated exemplars**	
Chinese prime [English translation]	English target	Chinese prime [English translation]	English target
lǎoshī (老师) [teacher]	teacher	*qīngwā* (青蛙) [frog]	teacher
30 non-living related exemplars		**30 non-living unrelated exemplars**	
Chinese prime [English translation]	English target	Chinese prime [English translation]	English target
shūběn (书本) [book]	book	*chúfáng* (厨房) [kitchen]	book

Table 12. A summary of the types of stimuli used in the priming experiment in the L1 to L2 condition. The same stimuli were used in the L2 to L1 condition but the order of the languages was reversed.

In order to ensure that the participants would not rely on the expectancy strategy (subsection 2.5.1, chapter two) during the priming task, apart from the critical stimuli (related-unrelated), a list of 20 fillers was created, which represented ten living and ten non-living exemplars. The fillers were created in such a way that the target fillers were preceded by primes that represented the opposite category, i.e. living prime preceded non-living target and/or non-living prime was followed by living target (examples of fillers are given in Table 13). The complete list of fillers used in the priming experiment is attached in Appendix 7. The relatedness proportion (RP) within each list was equal to 0.25 (60 critical items and 20 fillers) and such a level of RP was introduced in accordance with the suggestion made by Altarriba and Basnight-Brown (2007) in order to reduce the use of the expectancy strategy

Chinese primes [English translation]	English targets
living	**non-living**
qīngwā (青蛙) [frog]	pocket
tùzi (兔子) [rabbit]	shop
non-living	**living**
yǐzi (椅子) [chair]	judge
fángmén (房门) [door]	king

Table 13. Examples of fillers used in the L1 to L2 priming task.

The animacy decision task involved a 2 x 2 x 2 design. The independent factors were as follows: prime relatedness (related versus unrelated), language group (from L1 to L2 and from L2 to L1), and modality (visual and auditory). In the subject analysis, the first factor was chosen as a within subject factor, whereas the priming direction and the modality were kept as between subject factors. In the item analysis, all three factors were within item variables.

3.3.2 Procedure

In this study, four priming tasks were designed, i.e. (1) visual L2 to L1, (2) visual L1 to L2, (3) auditory L2 to L1, and (4) auditory L1 to L2. Since the procedure for the visual and auditory tasks varied, they are going to be described separately.

3.3.2.1 Visual priming experiment

The masked priming task was designed based on a similar procedure to that in Jiang (1999, Experiment 4, 5), Jiang and Forster (2001, Experiment 1) and Schoonbaert et al. (2009, Experiment 1, 2, 3, 4). The experiment started with a presentation of instructions on the computer screen. The same instructions were displayed in English for the L1 (Chinese primes) to L2 (English target) condition and in Chinese for the L2 (English prime) to L1 (Chinese target) condition. The choice was motivated by the fact that the participants were requested to attend only to the target words. The instructions stated that participants were to press the YES key (L key on the computer keyboard), if the presented word/target was a living exemplar and the NO key[79] (S key on the computer keyboard) if the presented target was not a living exemplar (i.e. if it was a non-living one). For instance, if they saw or heard the word *horse* (living) they were asked to press the YES key, whereas if they saw or heard the word *stone* (non-living) they were required to press the NO key. The instructions also included the information about a trial session and the number of practice trials. The trial session, consisted of 12 examples (four related words, four unrelated words and four fillers) (Appendix 8) and allowed the participants to familiarize themselves with the task requirements. The trial session was followed by the main experiment, which comprised 80 trials in total (60 related and unrelated pairs of words and 20 fillers of unrelated pairs of words).

Each experimental trial consisted of five sequential visual events. First of all, a forward mask was presented for 500ms and was presented in a form of ten cross hash marks (##########). Apart from acting as a mask for the prime, it also served as a fixation point. Next, the prime was shown for 30ms, followed by a blank interstimulus interval of 50ms. Fourth, a row of ten italic dollar marks *($$$$$$$$$$)*[80] was presented as a backward mask for 150ms. The purpose of introducing a backward mask was to disguise the prime and also to ensure that the participants would have enough time to process L2 primes (Jiang, 1999). Finally, the target word appeared and remained on the screen until the participant's response, or until 2500ms elapsed. The inter-trial interval was not fixed and the participants moved on to the next trail as soon as they responded to the previous one. The SOA was equal to 230ms, being kept relatively short but at the same time long

[79] Appropriate YES and NO labels were put over the L and S key on the computer keyboard.
[80] It was observed during the design stage of the task that the use of identical forward and backward masks resulted in a *pop-out effect* of the prime. That is why another form of the backward mask was used.

enough to allow for the processing of a prime to take place. The primes were surrounded by a forward and backward mask to assure that automatic processing would occur. The reaction times were measured from the target's onset until the response was given. Figure 19 below illustrates the procedure of one experimental trial in the visual priming task.

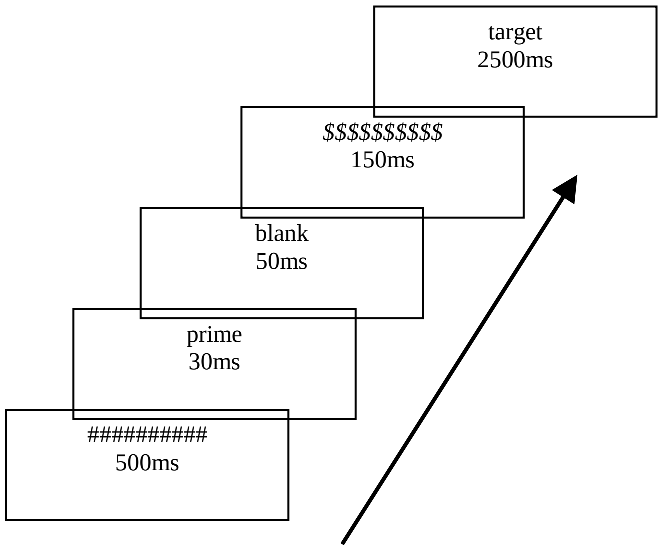

Figure 19. A visual representation of a single trial in the masked visual priming task.

The primes and the targets were displayed in the middle of a computer screen. The English and Chinese primes were displayed in font size 36, whereas the targets were in font size 48. The English words were written in the Arial Black (Regular) font, whereas the Chinese words were written in the SimSum one. The usual presentation of primes in lowercase and targets in uppercase was not possible in this study because of the difference in scripts. The forward and backward masks were displayed in Arial Black font size 36. The type of the characters used as forward and backward masks differed in order to avoid the, so called, *pop-out effect* of the prime (Finkbeiner et al., 2004; Schoonbaert et al., 2009), i.e. a situation when a prime presented in between two identical masks may appear to stand out from the background and thus may consciously be visible to the participants. The order of the trials was randomized for every participant. The stimulus presentation and RT were controlled by the Superlab 4.5 software.

3.3.2.2 Auditory priming experiment

While in the visual format of the task, the stimuli were presented in the middle of the 14-inch computer screen, in black colour on a blue background, in the auditory version of the task, the stimuli were presented through a set of headphones. These were read out loud by a male native speaker of English and a male native speaker of Mandarin Chinese. All the words were recorded twice with the use of the Audacity 1.3 software. The recording was repeated in order to ensure that the words in both languages were read out clearly and at approximately the same rate. Once a list of audio files was compiled, the words were edited with the Cool Edit Pro software. The editing involved trimming each sound before and after the word was spoken in such a way that only the word itself was audible. Also, each word was time compressed to 50% of its original duration and was embedded in white noise. The time compressed words served as primes in the experiment. The time compressed English primes were from 275ms to 400ms long with a mean of 340ms (SD= 32), whereas the Chinese were 325ms to 400ms long with a mean of 370ms (SD=28ms). The targets were played at a normal speech rate. That is, the English targets were from 550ms to 800ms presented for a mean duration of 680ms (SD=64ms), whereas the Chinese were from 650ms to 800ms long, with an average of 740ms (SD=57ms) in length. The exact time duration of all the primes and targets (including practice trail stimuli and fillers) is given in Appendix 9. The audio files with recorded words were presented to the participants, similarly to visual stimuli, by the Superlab 4.5 software.

Two auditory experiments were designed, which followed the same experimental procedure however; the language in which the primes and targets were presented was reversed. In one of the experiments the primes were presented in Chinese and the targets in English (L1 primes to L2 targets), whereas the other contained L2 primes and L1 targets. Each of the auditory experiments consisted of 12 practice trials and 80 main experimental trials, with each starting with a white noise that lasted for one second. After the initial 300ms of the white noise display (forward mask), a time-compressed prime embedded in the white noise was played for a mean duration of 340ms (Chinese primes) or 370ms (English primes). Once the prime presentation ended, the white noise (backward mask) carried on for another 360ms or 330ms. Next, the target was played for a mean duration of 681ms (English targets) or 740ms (Chinese targets). At the end of each trial an interstimulus interval of one second was introduced to mark the ending of a single trial. The sequential presentation of the auditory items in a single trial is visually presented in Figure 20.

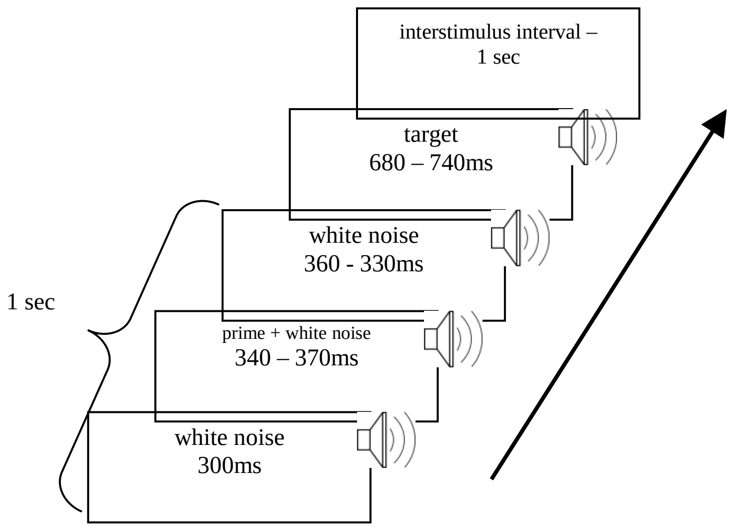

Figure 20. A visual representation of a single trial in the masked auditory priming task.

The procedure of the auditory priming task resembled the original procedure used by Kouider and Dupoux (2005b) and Dupoux et al. (2008). In both of these studies as well as in this project, the primes were time compressed to 50% of their original duration[81]

[81] In Kouider and Dupoux (2005) the primes were time compressed to 35%, 40%, 50%, or 70% of their original duration. That is, the prime duration was manipulated in order to estimate the prime audibility, i.e. a rate at which the participants were aware of the primes. The results showed that at 35% and 40% rates they were mostly unaware of the primes; however, at the 50% and 70% rates they reported hearing the primes. However, at 35% and 40% rates the strength of the stimuli (duration or energy) and at the same time its quality is reduced. Consequently, in this project, a 50% time compression rate was used and to ensure that the participants would not be aware of the primes, they were embedded in white noise.

and they were preceded as well as being followed by white noise (by forward and backward masks). However, the procedure used in this research differed in two aspects from those of Kouider and Dupoux (2005b) and Dupoux et al. (2008). First, the mask in this project was used in the form of background conversation white noise, rather than white noise obtained by reversing the primes. This was used because it more closely resembles natural human speech as compared to undistinguishable white noise created by reversing the prime word recording. Secondly, the targets were presented on their own, without the simultaneous presentation of a mask, whereas the primes were embedded in white noise. Such a decision was made to ensure that the target words were clearly audible and easily recognisable by the participants as well as that the primes were not consciously processed.

The visual and auditory experiments in this study took place in a quiet room on the campus of the HKU or the CUHK. Each participant was tested individually. The participants were seated at a table in a comfortable position to reach the keyboard of the laptop (participants who took part in the auditory task wore a pair of headphones through which the stimuli were played). First of all, they were familiarized with the experimental procedure and after a short introduction given by the researcher, the instructions were presented in a written format on the computer screen for both the visual and auditory tasks (the instructions given to the participants are in Appendix 10). Next, the participants practiced giving answers in a trial session, which was then followed by the main experimental period. The whole procedure lasted about five minutes for the visual task and about 10min for the auditory.

The participants were randomly assigned to one of four experimental conditions. About half (67) took part in the visual form of the experiment, whilst the remainder (59) took part in the auditory task. Furthermore, within each modality group, about half of the participants performed the priming task from L1 (Chinese primes) to L2 (English targets) and the rest completed the task in the opposite translation direction, i.e. from L2 (English primes) to L1 (Chinese targets). The assignment of the participants to each experimental condition, and the overall numbers of participants in each group are outlined in Table 14.

assignment of participants to experimental conditions	
67 visual modality	
35 L1 primes – L2 targets	**32** L2 primes – L1 targets
59 auditory modality	
29 L1 primes – L2 targets	**30** L2 primes – L1 targets

Table 14. A summary of the number of participants that were assigned to each priming task.

3.4 Design of the semantic judgement tasks and procedure

In order to address the fourth hypothesis, i.e. in order to measure the extent to which Chinese-English bilinguals share cognitive representations of a semantic domain, here the domain of animals, a semantic judgement task was designed (Appendix 11). The task was based on similar materials to those used by Herrmann and Raybeck (1981) and Romney et al. (1995). Both these studies investigated the semantic domain of animals; however, Herrmann and Raybeck (1981) focused on comparison of the similarities in meaning between six cultures (Spanish, Vietnamese, Chinese, Haitian, Greek, and American), whereas Romney and associates (1995) worked with monolingual English participants. The design of the task used in this project differed slightly from those employed in these studies. Regarding this, Herrmann and Raybeck (1981) requested the participants to judge the similarity of 12 animal terms (*sheep*, *goat*, *cow*, *horse*, *deer*, *bear, lion, pig, dog, cat, mouse* and *rabbit*) on a four point scale, whereas Romney and colleagues (1995) asked them to judge the similarity of 21 animal terms (*antelope, beaver, camel, cat, chimpanzee, chipmunk, cow, deer, dog, elephant, giraffe, goat, gorilla, horse, lion, monkey, rabbit, rat, sheep, tiger* and *zebra*) on a 20 point scale. In the task employed in this project, the participants were asked to judge 12[82] animal terms on a 6 point scale, these being: *ant, cow, elephant, panda, camel, spider, bee, lion, monkey, butterfly, rabbit* and *tiger* (Appendix 12). Eight of the items were the same as some of the words used by Romney et al. (1995) and Hermann and Raybeck (1981). However, it was not possible, in this project, to use exactly the same stimuli as in the previous studies due to the fact that many of the English words when translated to Chinese are represented by monosyllabic translation equivalents (the words used in this project were all bisyllabic Chinese lexical units). All chosen words were exemplars of animate beings, i.e. they were all names of animals. All together, the complete list contained sixty-six pairs of animal terms (Appendix 13).

Based on the information obtained from previous studies that employed a multidimensional scaling technique (e.g. Hermann and Raybeck, 1981[83]; Romney et al., 1995[84]), the group of participants needed for the task was estimated to be around 100. Thus, about one third of the bilingual (40) and all of the monolingual participants (39) were asked to take part in this task. They were all tested individually and were seated at a table, in a comfortable position. The task was presented in electronic format and they were asked to mark similarity of words by clicking on a box next to a chosen number, with 6 indicating very similar and 1 standing for very dissimilar. Half of the bilingual

[82] Shoben (1983:486) indicated that as a general rule of thumb, no less than 9 or 10 stimuli should be used in a two-dimensional scaling.
[83] Hermann and Raybeck (1981) compared data obtained from six groups of participants from six countries. Each group had from 15 to 24 participants.
[84] Romney et al. (1995) had a sample of 122 participants from a variety of ethnic and linguistic backgrounds.

participants taking part in this task filled in the English version, whilst the other half completed the Chinese version. Moreover, English monolingual participants filled in the English version, whereas the Chinese were requested to complete the Chinese one. The assignment of participants to each task is presented in Table 15 and on average, it took about three to four minutes for the participants to complete the task.

assignment of participants to the tasks	
40 bilinguals semantic judgment task	
20 bilinguals Chinese version of the task	**20 bilinguals** English version of the task
39 monolinguals semantic judgment task	
16 Chinese Chinese version of the task	**23 English** English version of the task

Table 15. A summary of the number of participants that were assigned to each semantic judgment task.

3.5 Piloting stage

All of the research tools, i.e. the questionnaires, the priming experiments, and the semantic judgement tasks were piloted, before the main stage of data collection took place. The three piloting phases are presented in detail below.

3.5.1 Piloting the questionnaires

All questionnaires (bilingual, English monolingual, Chinese monolingual) were piloted with 12 bilingual Chinese-English speakers. All these participants were asked to pay special attention to questions or parts of questions that might not have been easily understood or which might have introduced ambiguity. While they filled in the questionnaires, the researcher measured the amount of time needed to complete the task. This measure was employed in order to establish the overall timing of the whole experimental procedure. After finishing the questionnaires, the participants were requested to give feedback on the clarity, cohesiveness, and appropriateness of the questions, timing, and any other aspects, which they found important to the completion of the task. All relevant suggestions were taken into consideration and were incorporated into the questionnaires that were administered to the main experimental groups. For instance the word 'sibling', used in questions 11 and 12 of the original bilingual questionnaire, was changed to 'brothers and sisters' for easy comprehension. Furthermore, the question regarding right and left handedness was modified. One more response choice was added, namely 'both' as some participants reported to have been born left-handed, but had then been extensively encouraged by parents and teachers to use their right hand to write or to use chopsticks. Nonetheless, data from participants who indicated they were ambidextrous was not included in the main data collection stage.

3.5.2 Piloting the priming experiments

In order to establish the optimal presentation length of the prime, i.e. allowing for processing of the primes without being consciously aware of them, four separate visual priming experiments were designed for piloting. In two of these the primes were presented in Chinese for 30ms or 45ms, whereas the targets were presented in English. In a further two experiments the language order was reversed (English primes and Chinese targets) but the duration of the primes was kept the same.

The visual priming experiment was piloted with eight bilingual Chinese-English speakers. Four of the students took part in the task with Chinese or English primes presented for 30ms, whereas the other four saw these for 45ms. Furthermore, two auditory priming experiments (L1 primes to L2 targets and L2 primes to L1 targets) were designed and piloted with four different participants. Each of the participants was tested individually in a quiet room and was seated at a table in front of a computer screen, being requested to press buttons on the keyboard in response to words presented on it.

After completion of the task, the participants were requested to provide feedback regarding the visibility of the primes, the clarity of presented targets (both visual and auditory), and the timing required to finish the task. This also focused on the overall aesthetics of the task, i.e. the size of the font, the colour of the words and the background as well as the quality of the auditory stimuli, i.e. loudness and clarity. The participants were also requested to comment on the overall experience of taking part in the experiment. That is, most of the participants who took part in the 45ms primes display reported seeing the primes consciously. They also reported that some of them (unrelated primes) interfered with their decisions about the target words. On the other hand, the informants who participated in the 30ms prime presentation either reported not seeing the primes at all or reported to have seen them, but too briefly to be able to read them and for this reason prime duration was set at 30ms in the visual condition. Furthermore, all relevant suggestions were taken into consideration and were incorporated into the main experimental stage. For example, the suggestion regarding using a computer mouse rather then a touch pad on the laptop was incorporated into the main experiment. All in all, the piloting stage allowed for the establishment of the prime duration length in the visual priming.

In addition, two auditory priming task, i.e. from L1 to L2 and L2 to L1 were also piloted with a group of four bilingual participants. Those participants who took part in the auditory version of the task did not report hearing the primes. They reported hearing some ‘noise’ or ‘rustle’, as they described the white noise, but when asked to report if they could hear any words played during the white noise, all four of them responded negatively. Finally, the piloting allowed for clarifying the instructions given to the participants, which were kept short but informative.

3.5.3 Piloting the semantic judgement tasks

The semantic judgement task was piloted with eight bilingual Chinese-English students, with half of them receiving the task in English and another half in Chinese. They were asked to rate how similar or dissimilar were presented groups of words and to provide feedback regarding comprehension of the task instructions, timing, and its layout. All relevant suggestions were taken into consideration and were incorporated into the main experimental stage. For instance, two of the originally selected animal terms were changed in order to allow for a greater variability in data and thus a greater distribution of them when presented spatially on the conceptual map. This change was introduced as the initial analysis revealed that some data was clustered.

3.6 Ethical consideration

This study followed the Ethical Principles for Conducting Research with Human Participants published by the British Psychological Society (2009) and the Good Practice Guide for Students published by British Association for Applied Linguistics (2000). Furthermore, it received ethical approval from the Education and Management Research Ethics Panel at King's College, London (reference number: REP(EM)/10/11-61) and from the Human Ethics Research Committee for Non-clinical Faculties at the University of Hong Kong (reference number: E4120611). A number of measures were undertaken in order to make sure that the participants did not experience any psychological or physical discomfort during the experimental procedure. Prior to the data collection stage, all participants were familiarized with the purpose of the research and the methods used. Furthermore, before taking part in the experimental session each was presented with a consent form and information sheet (Appendix 1A, 1B, and 1C)[85], which contained information about anonymity and confidentiality of the collected data. The form also

[85] The original English monolingual information sheet and consent form were translated into Mandarin Chinese by a native Mandarin speaker. The English forms (1B) were administered to English monolingual participants, whereas those in Chinese (1C) were used with the Chinese participants.

stressed the fact that the participants had the right to withdraw from the study at any stage. All were offered a box of chocolates or a Starbucks voucher (HK$25 about £2 in value) in gratitude for their time and taking part in the experiment. Each participant was also given a chance to ask any questions and/or ask for a clarification regarding the experiment after the testing stage. Many of the students used this offer to take the opportunity to learn more about priming experiments and the bilingual mental lexicon.

CHAPTER FOUR

ANALYSIS AND RESULTS

The results obtained in this study are presented in this chapter. First, the focus of this part of the thesis is on the analysis of the data from the implicit priming experiments administered to the bilingual participants. The subject and item analyses performed on latency data and error rates are presented. The outcomes of the analyses of variance demonstrate the main effects and the interactions between the independent factors. These outcomes are then further used to address the notions of the priming effect, the priming asymmetry effect, and the impact of modality on language processing. In the last section of this chapter the concentration is on the multidimensional scaling analysis of the data obtained from the semantic judgement task. This part of the analysis addresses the notion of the semantic overlap between Chinese and English languages in bilingual speakers.

4.1 Analysis of data from the priming tasks

Latency data and error rates from the four experiments: (1) L2 to L1 visual priming, (2) L1 to L2 visual priming, (3) L2 to L1 auditory priming, and (4) L1 to L2 auditory priming, were analyzed in a single design with two three-way repeated measures ANOVAs in SPSS (one analysis of variance was performed on RTs and one on ERs). The outcomes of the two ANOVAs are reported separately in the subsections that follow. Participants (F_1) and items (F_2)[86] were treated as random variables, RTs and ERs as dependent variables, and prime relatedness (related and unrelated targets), language group (L2 to L1 and L1 to L2), and modality (visual and auditory) as independent

[86] It is a common practice in the field of psycholinguistics to look at data from two different angles, i.e. participants and items. This is because, in the same way as a sample of participants is selected from a larger population, a sample of words (experimental stimuli), here concrete words, is chosen from a much larger pool of words that are available in a given language (Raaijmakers et al., 1999).

variables. The prime relatedness was a within subject variable, and the language group and modality were between subject variables in the subject analysis. This is because the participants were assigned to one of the four conditions: (1) L2 to L1 visual priming, (2) L1 to L2 visual priming, (3) L2 to L1 auditory priming, and (4) L1 to L2 auditory priming. In the item analysis, the three variables (prime relatedness, language group, and modality) were within item variables. The same items (related and unrelated) were used in the visual and auditory modalities in the two language groups, i.e. in L2 to L1 and L1 to L2.

4.1.1 Descriptive statistics – reaction times

Mean reaction times were computed for the related items (translation equivalents) and unrelated items (words that did not share meaning) across four conditions: (1) L2 to L1 visual priming, (2) L1 to L2 visual priming, (3) L2 to L1 auditory priming, and (4) L1 to L2 auditory priming. All obtained results from the subject analysis[87] are recorded in Table 16 and in Figure 21 below.

	related	**unrelated**
L2 to L1 visual	743.36	752.98
L1 to L2 visual	936.01	1,056.07
L2 to L1 auditory	1,290.92	1,292.12
L1 to L2 auditory	1,598.55	1,883.34
total	1,119.18	1,213.36

Table 16. Mean reaction times in ms – subject analysis

[87] The mean reaction times obtained in the item analysis resemble, to a large extent, those results demonstrated in the subject analysis.

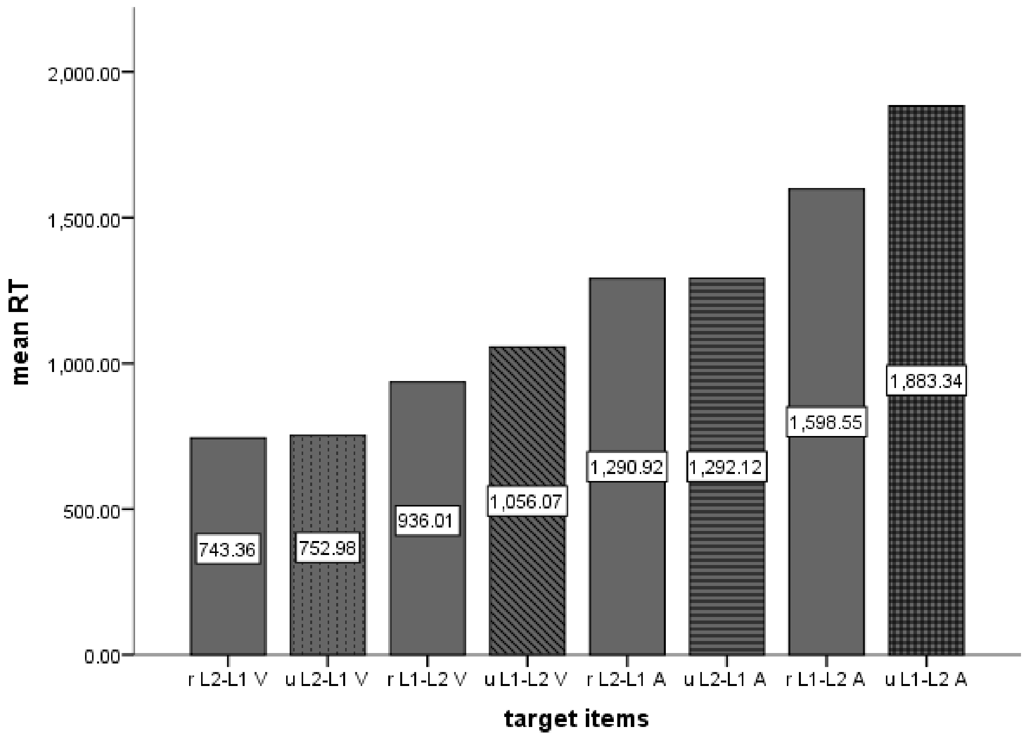

Figure 21. Mean reaction times in ms for related (r) and unrelated (u) target items in two language groups: L2 to L1 and L1 to L2 in two modalities: visual (V) and auditory (A) – subject analysis

4.1.2 Main effects – reaction times

Before the analyses of variance were conducted, all practice trials (12) and fillers (20) were removed so that only the critical items (60 related and unrelated target items) were left. Next error analysis was run, which allowed for identification of any participants and any items that should be excluded due to a high percentage of errors (above 50%). In consequence, data from 2 participants was excluded and 5 items (*groom, fox, doll, clown, seal*) were discarded from both modalities and both language groups in the final analysis. Most of the errors on items were made in the auditory modality when the participants were asked to respond to English targets, which suggests that the erroneous items were difficult to understand. This situation might have occurred either owing to the poor recording quality of the words or the speed of stimuli presentation. For instance, it is likely that the word *groom* might have been understood as *broom*, the word *fox* might have been heard as *box*, and the word *clown* could have been understood by the participants as *cloud* or *crown*. Hence, instead of giving a correct answer ('yes' to a living entity) they responded erroneously by pressing a 'no' button. Also, it has to be admitted that the word *seal* is ambiguous, for it might refer to a living entity, an animal, and also to a non-living thing, namely, a stamp. Furthermore, the word *wáwa* (娃娃) which stands for a *doll* in English, can be understood in Chinese as a *baby* (a living entity) or as a *doll* (a non-living thing). The ambiguity of the items might have led to a high percentage of participants' errors. It also needs to be made clear that only correct responses, i.e. 'yes' responses to the words representing living entities and 'no' answers to the words standing for non-living things, were analyzed. That is, all incorrect answers were filtered and discarded. Finally, all outliers, i.e. RT that were less than 200ms and 2.5*SD* below or above the participants' mean word reaction time were removed. This resulted in the elimination of around 2% of responses.

The main effects obtained in this study were all statistically significant. To begin with, the ANOVA carried out on the correct RTs produced a significant main effect of the prime relatedness. This means that the targets which were preceded by translation equivalents e.g. *lǎoshī* (老师) - teacher[88] were recognized faster (M = 1119ms, SD = 401ms) than were those preceded by unrelated words, e.g. *chǒngwù* (宠物) - teacher[89] (M = 1213ms, SD = 472ms). This difference was statistically significant in both the subject and item analyses [F_1 (1, 96) = 43.82, $p < 0.001$; F_2 (1, 55) = 38.13, $p < 0.001$]. The reported difference of 94ms, exemplified graphically in Figure 22[90], can be interpreted as a priming effect. This means that the recognition of the related targets was

[88] The Chinese word *lǎoshī* (老师) means *teacher* in English.
[89]The Chinese word *chǒngwù (*宠物) stands for *pet* in English.
[90] Each main effect is illustrated in the form of a graph based on the subject analysis Also, in the discussion on each main effect references are made to the RTs from the subject analysis. This is to ease comprehension, given the amount of data available.

facilitated by a prior subliminal presentation of their translation equivalents as primes, what resulted in shorter reaction times.

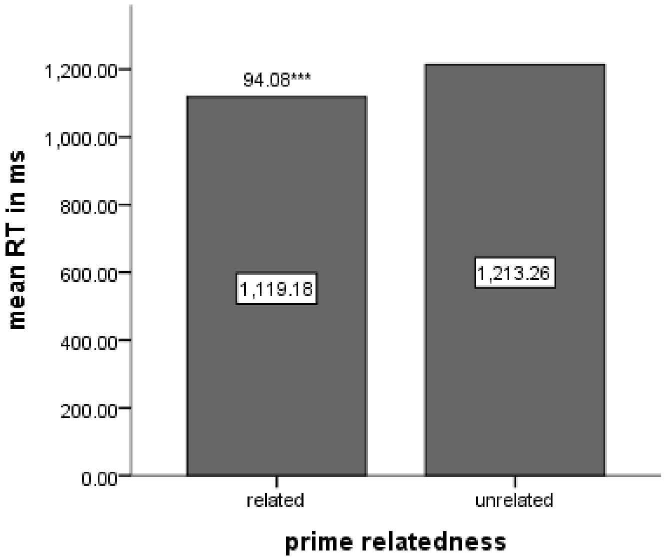

Figure 22. Mean RTs in ms for the related and unrelated target items; the difference in RTs is indicated on the top of the lower bars; ***p < 0.001.

Furthermore, the main effect of the language group on the RTs was also significant in both the subject and item analyses [F_1 (1, 96) = 57.04, $p < 0.001$; F_2 (1, 55) =148.02, $p < 0.001$]. This effect indicates that the answers given to the target items presented in the L2 to L1 language group, e.g. teacher - *lǎoshī* (老师) were faster (*M* = 1009ms, *SD* = 328ms) than those recorded for words in the opposite language group, e.g. *lǎoshī* (老师) - teacher (*M* = 1352ms, *SD* = 474ms). This significant difference of 342ms is visible in the graphical comparison presented in Figure 23 below. In the L2 to L1 language group, the participants attended to words in Mandarin Chinese, their native as well as dominant language. This is why the answers provided in the L2 to L1 condition might have been quicker than those provided in the L1 to L2 language group.

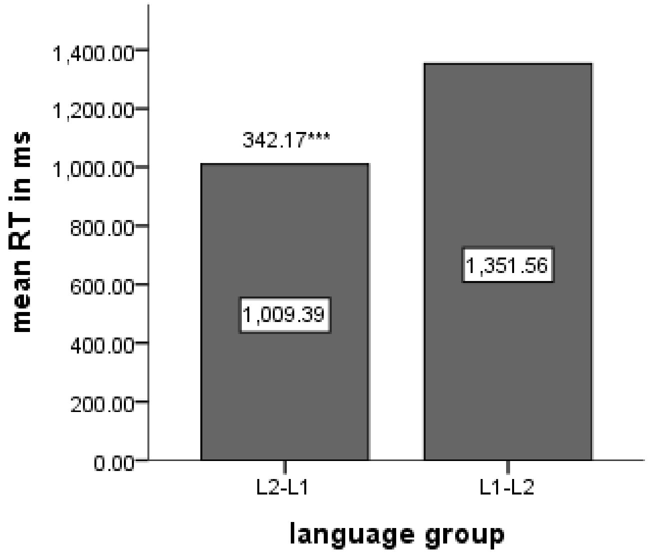

Figure 23. Mean RTs in ms of the target items in L2 to L1 and L1 to L2 language group; the difference in RTs is indicated on the top of the lower bars; ***p < 0.001.

Finally, the main effect of the modality was significant in both the subject and item analyses [F_1 (1, 96) = 194.70, $p < 0.001$; F_2 (1, 55) = 865.41, $p < 0.001$]. That is, the target words that were displayed on the computer screen in the visual modality were recognized faster (*M* = 862ms, *SD* = 238ms) than those that were audibly heard via a set of headphones (*M* = 1497ms, *SD* = 354ms). This difference of 634ms, as exemplified in Figure 24 below, can be attributed to either the mode of stimuli presentation or to the design of the tasks. It is likely that in the two modalities, the information about the words does not become available at the same rate. More specifically, in the visual modality, all of the information about the word is accessible right away on the screen. That is, the participants had access to orthographic, phonological, and semantic information; hence less time was needed in order to reach a decision about the word. On the other hand, in the auditory modality, the information unfolds slowly over time as/when the word is spoken (Degner, 2011). However, it is also possible that the design of the tasks could have yielded different patterns of results. In the visual and auditory tasks different length of the stimuli presentation was adapted (different SOAs), which was motivated by the need to measure automatic language processing.

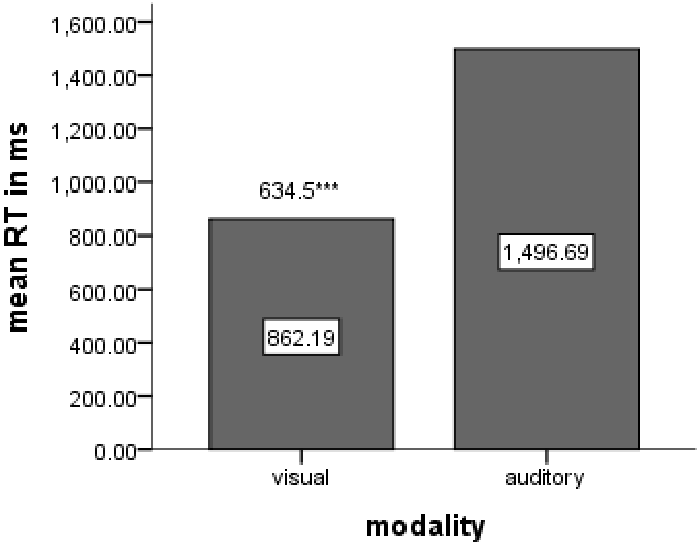

Figure 24. Mean RTs in ms of the target items in the visual and auditory modalities; the difference in the RTs is indicated on the top of the lower bars; ***p < 0.001.

4.1.3 Interactions – reaction times

The analysis of variance that was performed on the RTs indicated not only significant main effects of the prime relatedness, the language group, and the modality, but also significant two-way interactions as well as one three-way interaction. Next, these interactions were examined. The line graphs presented below demonstrate the interactions between the independent variables measured in terms of difference in RTs. Figures 25, 26, and 27 show two-way interactions[91] between the variables, whereas Figure 28 presents a three-way interaction between the three independent factors.

[91] Each interaction is illustrated in the form of a line graph, based on the subject analysis. Also, in the discussion of each plot references are made to RTs from the subject analysis. This is to ease comprehension, given the amount of data available.

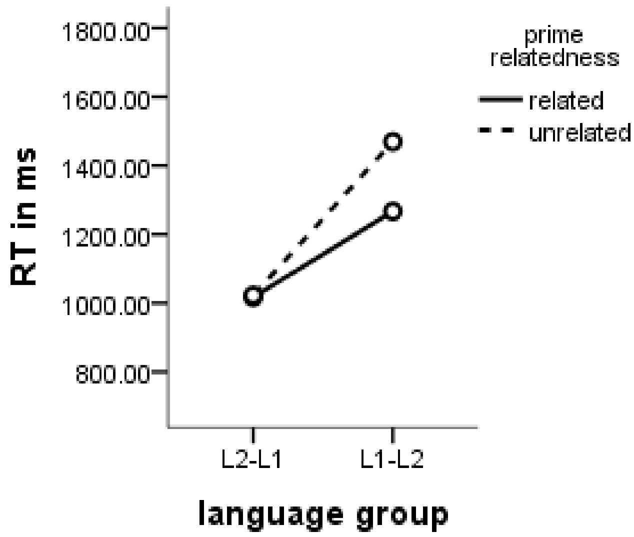

Figure 25. A two-way interaction between prime relatedness and language group.

The plot depicted in Figure 25 present a significant interaction between the prime relatedness (related and unrelated) and the language groups (L2 to L1 and L1 to L2) [F_1 (1, 96) = 39.38, $p < 0.001$; F_2 (1, 55) = 44.33, $p < 0.001$]. Moreover, the line graph shows that in the L2 to L1 language group, there was no difference in terms of RTs between the related (*M* = 1007ms) and unrelated target items (*M* = 1012ms); however, in the L1 to L2 language group, a difference in RTs was recorded. That is, the responses to the related target items were faster (*M* = 1252ms) than those given to the unrelated targets (*M* = 1451ms). This interaction clearly points to an asymmetry in the priming effects that has been recorded between the L2 to L1 condition (6ms) and the L1 to L2 one (198ms). Since this two-way interaction was significant, it was further examined by considering the results of a t-test. The outcomes demonstrated that the difference in RTs between the related and unrelated items in the L2 to L1 condition was not statistically significant in either the subject or item analyses [t_1 (51) = - .343, $p > 0.05$ and t_2 (109) = - 0.062, $p > 0.05$]. However, the difference reported between the related and the unrelated items in the L1 to L2 condition was greater in magnitude (198ms) and also statistically significant in both the subject and item analyses [t_1 (43) = - 6.524, $p < 0.001$ and t_2 (109) = - 7.672, p < 0.001].

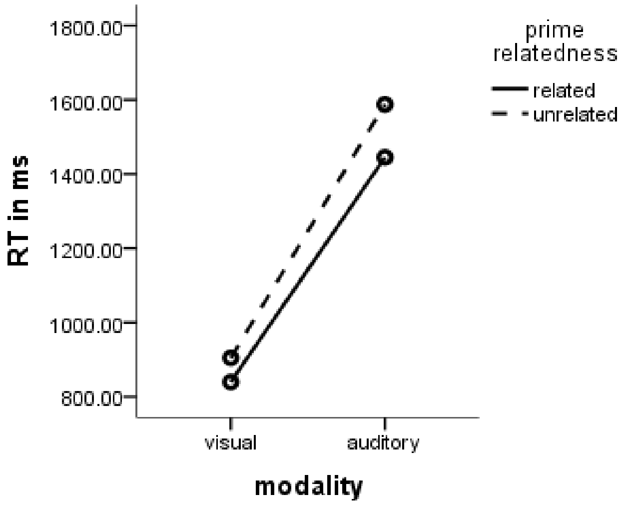

Figure 26. A two-way interaction between prime relatedness and modality.

The plotted lines illustrated in Figure 26 depict an interaction between the prime relatedness (related and unrelated) and the modalities (visual and auditory). In the visual modality, there seems to be a difference in RTs between the related (*M* = 832ms) and unrelated target items (*M* = 892ms). Also, in the auditory modality a difference between the two types of items has been noted (*M* = 1431ms - related; *M* = 1556ms - unrelated). The interaction between the prime relatedness and the modality was significant in both the subject and item analyses [F_1 (1, 96) = 6.19, $p < 0.05$; F_2 (1, 55) = 4.34, $p < 0.05$]. The combined effect of the prime relatedness and the modality produced a form of ‘asymmetry’ between the reported priming effects. That is, the priming effect in the auditory modality seems to be stronger than the one observed in the visual condition. This interaction was followed by a t-test and it was demonstrated that related items were recognised quicker than those unrelated in the visual modality. That is, the difference of 60ms reported between the two types of target items was statistically significant in both the subject and item analyses [t_1 (49) = - 3.378, $p < 0.001$ and t_2 (109) = - 4.726, p <

0.001]. Also, the difference in RTs between the related and unrelated items in the auditory modality proved to be statistically significant in both the subject and item analyses [t_1 (45) = - 3.804, $p < 0.001$ and t_2 (109) = - 4.393, $p < 0.001$].

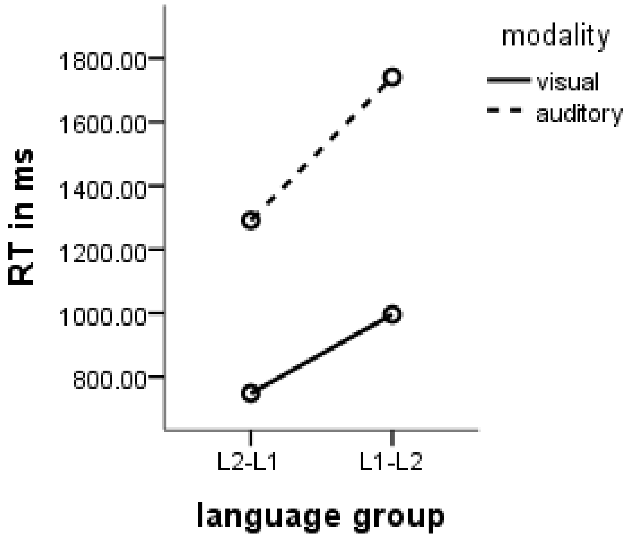

Figure 27. A two-way interaction between modality and language group.

The plotted lines shown in Figure 27 portray a significant interaction between the modalities (visual and auditory) and the language groups (L2 to L1 and L1 to L2) [F_1 (1, 96) = 4.76, $p < 0.05$; F_2 (1, 55) = 26.67, $p < 0.001$]. A difference in RTs can be observed between the two modalities in the L2 to L1 language group, where the responses in the visual modality (M = 748ms) were quicker than those in the auditory one (M = 1292ms). Also, a difference in RTs between the two modalities can be observed in the L1 to L2 language group. That is, responses in the visual modality (M = 996ms) were quicker than those in the auditory (M = 1741ms). Consequently, the combined effect of the modality and the language group produced particularly slow RTs in the L1-L2 auditory condition. To examine the interaction between the modalities (visual and auditory) and the language groups (L2 to L1 and L1 to L2) a paired-samples t-test was run. It emerged that items in the visual modality (748ms) in the L2 to L1 condition were responded to quicker than those in the auditory (1292ms) in the same condition. The difference between the two of 543ms was found to be statistically significant in both the subject and item analyses [t_1 (49) = - 15.090, $p < 0.001$ and t_2 (109) = - 29.160, $p < 0.001$]. Furthermore, the same pattern of results was reported for the L1 to L2 language group, i.e. the answers to the visually presented stimuli (996ms) were given faster than to the auditory ones (1741ms). This was a statistically significant difference in both the subject and item analyses [t_1 (41) = - 11.151, $p < 0.001$ and t_2 (109) = - 23.280, p < 0.001].

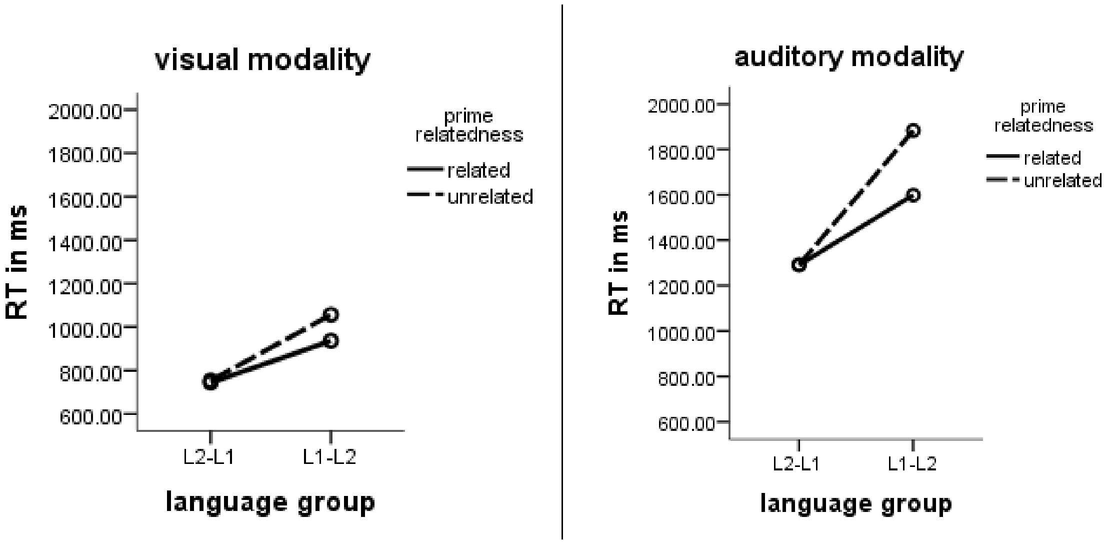

Figure 28. A three-way interaction between prime relatedness, language group, and modality.

The plotted lines depicted in Figure 28 demonstrate a three-way interaction between the prime relatedness, the language group, and the modality. A three-way interaction can be interpreted as two two-way interactions that vary across a third variable. As a result, we have two plots presenting two-way interactions between prime relatedness and language group that vary across the visual (left graph) and auditory (right graph) modalities. It can be observed that responses in the two modalities vary in terms of the reaction times in that the responses provided in the auditory modality were on average 600ms slower than those given in the visual. A detailed analysis of the graphs indicates that in the visual modality (left graph) in the L2 to L1 condition, there seems to be no difference in RTs between the related (M = 743ms) and unrelated target items (M = 753ms). In comparison, in the visual modality in the L1 to L2 language group, a difference in RTs between the two prime relatedness conditions was recorded (M = 936ms - related; M = 1056ms - unrelated). A similar pattern of results can be observed in the auditory modality (right plot), whereby in the L2 to L1 language group, there seems to be no difference between the responses given to related (M = 1291ms) and unrelated items (M = 1292ms). On the other hand, in the L1 to L2 condition, the answers given to the related items (M = 1599ms) seem to be faster than those given to the unrelated targets (M = 1883ms). The interaction between the three variables was reported to be statistically significant in both the subject and item analyses [F_1 (1, 96) = 7.60, $p < 0.01$; F_2 (1, 55) = 7.04, $p < 0.01$]. In sum, it seems that the combined effect of the three independent factors produced particularly slow answers to the unrelated words in the L1 to L2 auditory modality.

To learn more about the three-way interaction a paired-samples t-test was computed. The outcomes illustrated that there was a significant statistical difference in the scores for the related and the unrelated target items in the L1 to L2 visual priming experiment, both in the subject and item analyses [t_1 (22) = -3.681, $p < 0.001$ and t_2 (54) = -5.058, $p < 0.001$]. In contrast, the outcome of the analysis conducted on the RTs from the L2 to L1 visual priming was not statistically significant in either the subject or item analyses [t_1 (23) = -1.184, $p > 0.05$ and t_2 (54) = -1.105, $p > 0.05$]. That is, the related items were not recognized much faster than the unrelated words. Furthermore, the t-test conducted to compare the latency data from the L1 to L2 auditory priming experiment demonstrated that related words were responded to faster than those unrelated. This difference was statistically significant in both the subject and item analyses [t_1 (20) = - 6.091, $p < 0.001$ and t_2 (54) = - 6.150, $p < 0.001$]. Nonetheless, the results from the last comparison, i.e. L2 to L1 auditory priming, were not statistically significant. The related items were recognized only 1 sec faster than the unrelated ones. This difference was not significant in either the subject or item analyses [t_1 (24) = - 0.038, $p > 0.05$ and t_2 (54) = 0.384, $p > 0.05$]. These results demonstrate that there was a facilitative effect for the related target items in both modalities (visual and auditory), however, only in the L1 to L2 language direction. The effect obtained in the opposite language direction, i.e. L2 to L1, was small and not statistically significant.

All in all, the findings illustrated by the interactions and simple effects can be summarized as follows:

- there was a priming asymmetry effect between the priming effects reported in the L2 to L1 (6ms) and L1 to L2 (199ms) language groups,

- priming effects were observed in both modalities, i.e. visual (60ms) and auditory (125ms); the priming effect was seemingly stronger in magnitude in the latter,

- the responses provided to the visual stimuli were faster than those given to the auditory stimuli in both L1 to L2 and L2 to L1 language groups; also, the answers given in the L1 to L2 auditory condition were considerably slower than those given in the other conditions,

- there was a facilitative effect for the related items in both modalities (visual and auditory), but it was statistically significant only in the L1 to L2 language group; the answers provided to the unrelated words in the L1 to L2 auditory condition were seemingly slower as compared to the other conditions.

4.1.4 Descriptive statistics – error rates

Mean error rates were computed for all related (translation equivalents) and unrelated target items (words that did not share meaning) from the subject analysis[92]. Next, for easier presentation of the findings, the mean error rates were converted into percentages. The obtained descriptive statistics are displayed in Table 17 and Figure 29 below.

	related		**unrelated**	
	M	**%**	***M***	**%**
L2 to L1 visual	.70	2.52%	.93	3.41%
L1 to L2 visual	1.17	4.29%	1.48	5.34%
L2 to L1 auditory	1.36	5%	.92	3.3%
L1 to L2 auditory	2.62	9.68%	3.24	11.58%

Table 17. Mean error rates and percentage of error rates – subject analysis

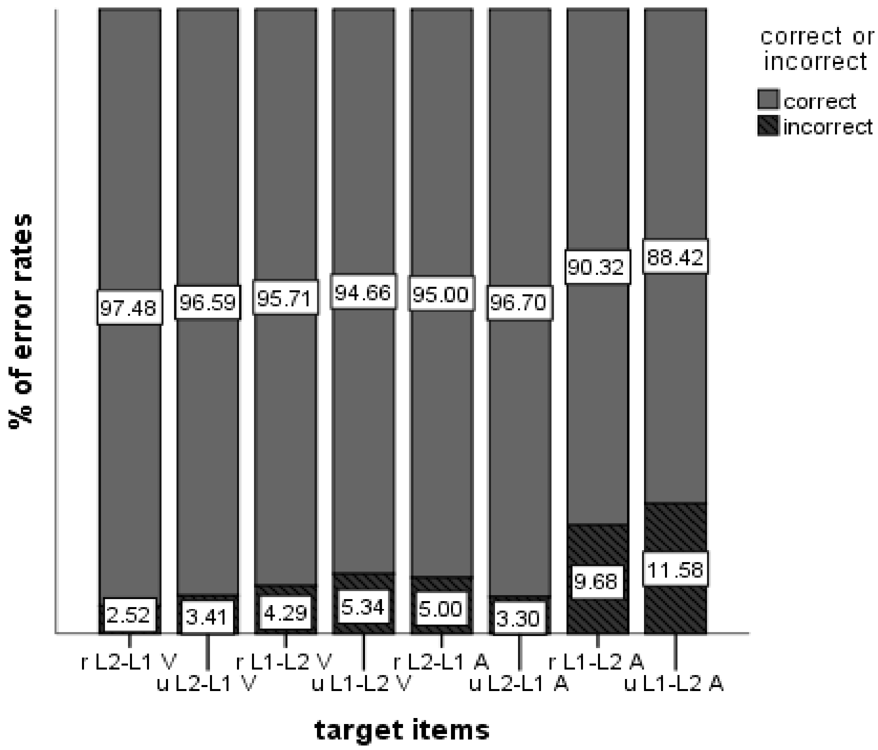

Figure 29. Percentage error rates and correct answers for related (r) and unrelated (u) target items in two language groups: L2 to L1 and L1 to L2 in two modalities: visual (V) and auditory (A) – subject analysis.

[92] The pattern or results obtained in the item analysis is similar to the results from the subject analysis.

4.1.5 Main effects – error rates

The first three hypotheses of this study were also tested with regard to the second dependent variable, i.e. the error rates/number of mistakes that the participants made while responding to the target items. It was expected that they would make fewer errors on the related items as compared to the unrelated ones, what would result in a priming effect measured as an increase in accuracy rates (Francis et al., 2010a). Similarly to the latency data, presented in the previous section of this chapter, error rates from four experiments: (1) L2 to L1 visual priming, (2) L1 to L2 visual priming, (3) L2 to L1 auditory priming, and (4) L1 to L2 auditory priming, were first of all analysed in a single design with a three-way repeated measure analysis of variance. The results reveal that two out of the three reported main effects were statistically significant; the details are presented below.

It was demonstrated that the main effect of the prime relatedness on ERs was not statistically significant in either the subject or item analysis [F_1 (1, 96) = 0.950, $p > 0.05$; F_2 (1, 55) = 0.749, $p > 0.05$]. This means that the related target items, e.g. *lǎoshī* (老师) - teacher, were recognized by the participants at about the same accuracy rate as the unrelated ones, e.g. *chǒngwù* (宠物) - teacher. The percentage of mistakes made on the related items was equal to 5.14%, whereas those made on the unrelated targets were equal to 5.66% (Figure 30). This result cannot be interpreted as a priming effect.

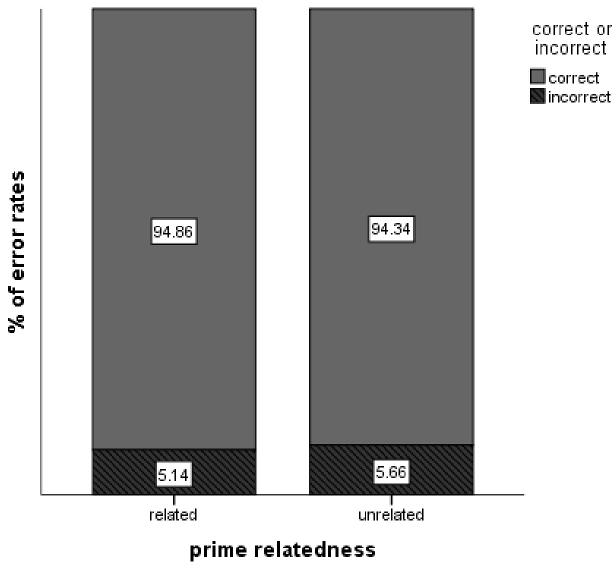

Figure 30. Percentage error rates and correct answers for the related and unrelated target items.

On the other hand, the main effect of the language group on ERs reached statistical significance in both the subject and item analyses [F_1 (1, 96) = 161.323, $p < 0.001$; F_2 = (1, 55) = 9.694, $p < 0.01$]. The average error rates for the two language groups, i.e. L2 to L1 and L1 to L2, were equal to 3.53% and 7.6%, respectively (Figure 31). This indicates that the participants made fewer mistakes when responding to the Chinese targets than English words. The same advantageous effect was demonstrated by the RTs data, which points again to the Chinese language dominance of this group of bilingual participants.

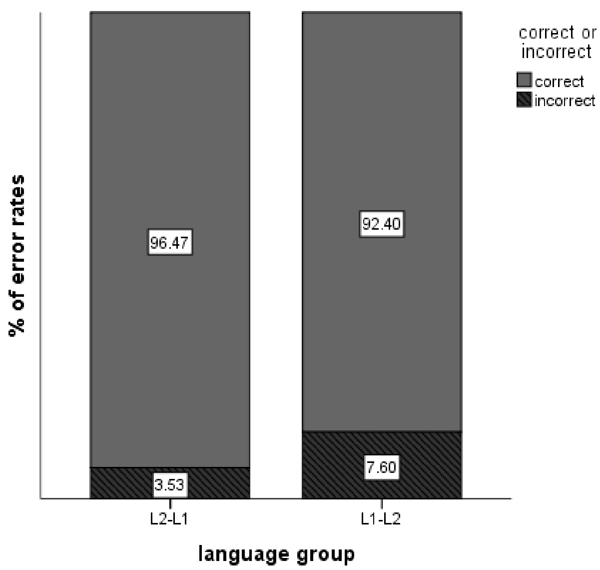

Figure 31. Percentage error rates and correct answers for the target items in the L2 to L1 and L1 to L2 language groups.

Finally, the main effect of modality on ERs was statistically significant in both the subject and item analyses [F_1 (1, 96) = 15.547, $p < 0.001$; F_2 (1, 55) = 8.955, $p < 0.01$]. The participants made more errors in the auditory (7.11%) as compared to the visual (3.81%) modality and this difference is graphically exemplified in Figure 32 below. This pattern of results was also demonstrated by the latency data, i.e. the participants responded quicker to the stimuli presented on a computer screen in the visual modality rather than to the same target words played via a set of headphones in the auditory modality.

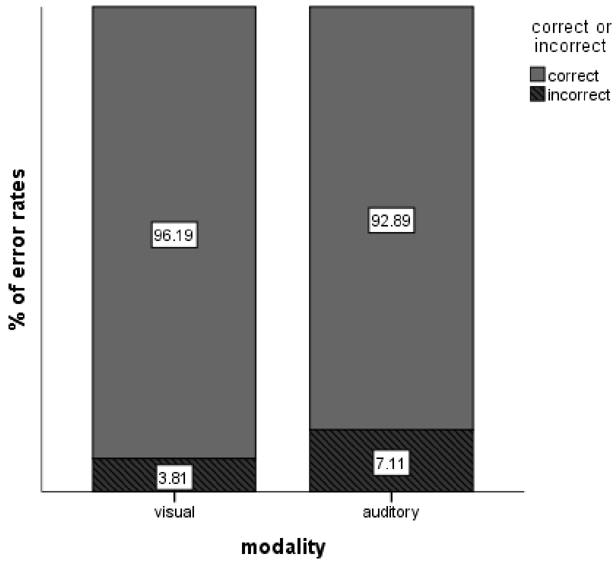

Figure 32. Percentage error rates and correct answers for the target items in the visual and auditory modalities.

4.1.6 Interactions – error rates

Similarly to the examination of the interactions carried out on RTs, the interactions between the independent variables on ERs were analysed. The results were plotted on to four line graphs presented in Figures 33 to 36 below. The plotted lines in Figures 33, 34, and 35 illustrate two-way interaction between the independent factors, whereas the graph in Figure 36 portrays a three-way one[93].

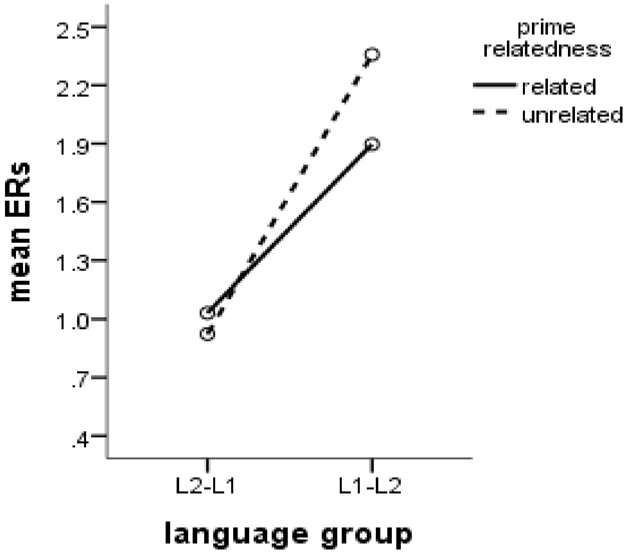

Figure 33. A two-way interaction between prime relatedness and language group.

The graphs shown in Figure 33 present a disordinal interaction between the prime relatedness (related, unrelated) and the language groups (L2 to L1 and L1 to L2). It can be observed that in the L2 to L1 condition the number of incorrect responses seems to be slightly lower for the unrelated items (M = 0.92) than for the related ones (M = 1.02). When the L1 to L2 language group is considered, it can be noticed that the related items (M = 1.86) seem to be recognized with a greater correctness as compared to the unrelated ones (M = 2.32). This interaction, however, was not statistically significant in either the subject or item analyses [F_1 (1, 96) = 2.486, $p > 0.05$; F_2 (1, 55) = 1.807, $p > 0.05$].

[93] Each interaction is illustrated once in the form of a line graph, based on the subject analysis. Also, in the discussion of each plotted line, references are only made to ERs from the subject analysis so as to ease comprehension given the amount of data available.

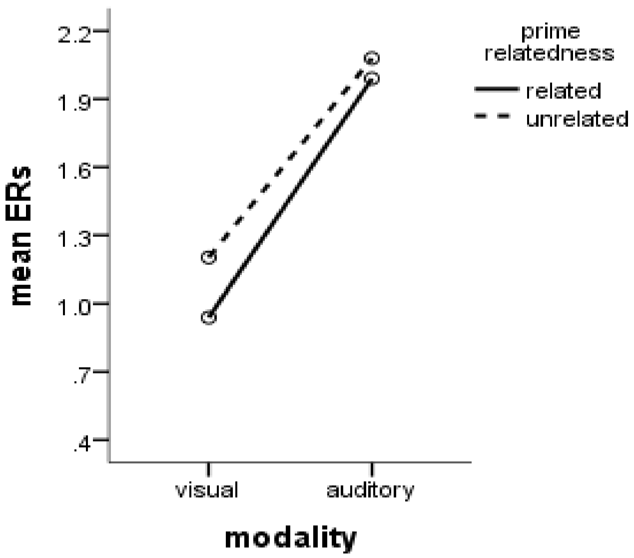

Figure 34. A two-way interaction between prime relatedness and modality.

The plotted lines illustrated in Figure 34 depict a two-way interaction between the prime relatedness (related, unrelated) and the modalities (visual and auditory). It can be read from Figure 34 that both related and unrelated target words were recognized at a very similar accuracy rate in both the visual and auditory modalities. Regarding the former, the mean error rate for the related items was equal to 0.92, whereas for the unrelated items it had a value of 1.18. In the auditory modality, the related items had a mean of 1.93 and the mean error rates for the unrelated items were equal to 1.98. The interaction between the two factors did not reach statistical significance in either the subject or item analyses [F_1 (1, 96) = 0.231, $p > 0.05$; F_2 (1, 55) = 0.385, $p > 0.05$].

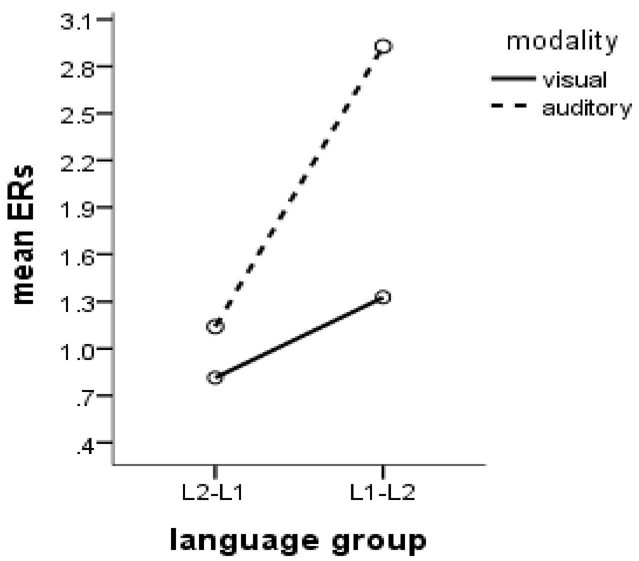

Figure 35. A two-way interaction between modality and language group.

The plotted lines presented in Figure 35 show an interaction between the two modalities (visual and auditory) and the language groups (L2 to L1 and L1 to L2). In the L2 to L1 language group, the difference between the error rates that the participants made in the visual (M = 0.8) and auditory (M = 1.1) conditions was relatively small. However, for the L1 to L2 language group, the number of errors between the two modalities is much greater (M = 1.3 – visual and M = 2.9 – auditory). Moreover, it was demonstrated that this interaction was statistically significant in both the subject and item analyses [F_1 (1, 96) = 6.826, $p < 0.01$; F_2 (1, 55) = 4.610, $p < 0.05$]. Since this interaction was significant a two paired-sample t-test was carried out to examine it further. A statistically significant difference in ERs was reported between the visual and auditory modalities in the L1 to L2 language group in both the subject and item analyses [t_1 (41) = - 4.446, $p < 0.001$ and t_2 (109) = - 3.721, $p < 0.001$]. When the ERs were compared in the opposite language group, i.e. L2 to L1, no statistically significant difference in the accuracy rates was observed between the visual and auditory modalities [t_1 (49) = - 1.205, $p > 0.05$ and t_2 (109) = - 0.907, $p > 0.05$]. The combined effect of the modality and language group produced the highest percentage of errors in the L1 to L2 auditory condition. A similar finding was exemplified by the interaction between the modality and language group on RTs.

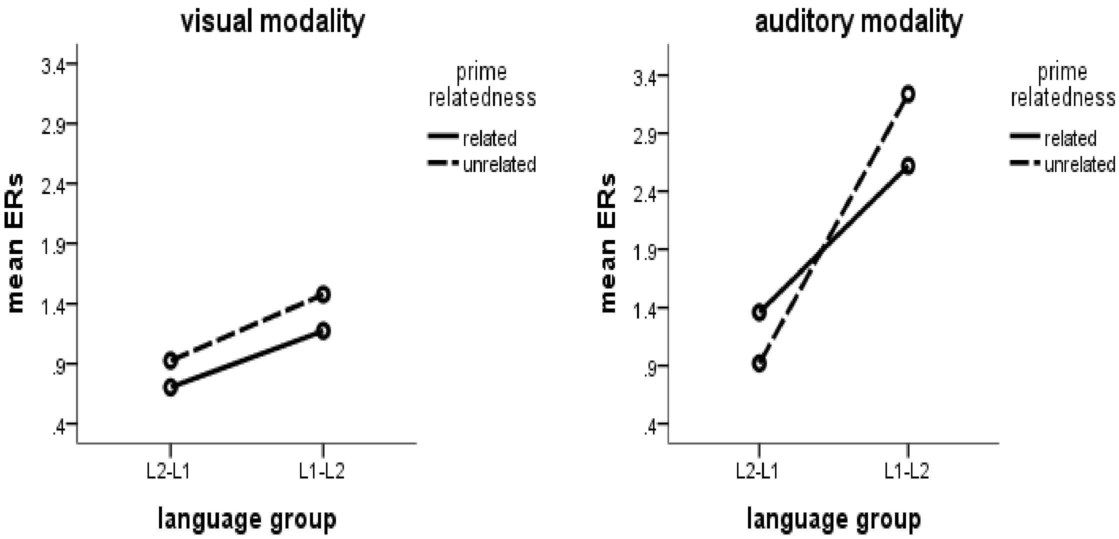

Figure 36. A three-way interaction between prime relatedness, language group, and modality.

The two graphs presented in Figure 36 illustrate a three-way interaction, i.e. two two-way interactions between the prime relatedness (related and unrelated) and the language group (L2 to L1 and L1 to L2) that vary across the third independent variable, the modality (visual and auditory). It can be read from Figure 36 (left graph) that there was a difference in ERs between the related and unrelated items in the L2 to L1 language group in the visual modality. Also, a difference in ERs is visible when the related and unrelated items are compared in the L1 to L2 condition in the same modality. However, the lines representing the related and unrelated items are almost parallel; therefore, it is possible to infer that this interaction is not statistically significant. A slightly different pattern of results can be observed in the auditory modality (right graph). That is, in the L2 to L1 condition, the unrelated items (M = 0.92) yielded fewer mistakes than the related ones (M = 1.36), but in the L1 to L2 condition, the pattern is reversed. Moreover, the answers provided to related items (M = 2.62) were more accurate than those given to the unrelated ones (M = 3.24). However, this interaction was shown not to be statistically significant in either the subject or item analyses [F_1 (1, 96) = 1.822, $p > 0.05$; F_2 (1, 55) = 1.116, $p > 0.05$].

To conclude, the interactions between the independent variables performed on the ERs indicate that answers given to visually presented words were more accurate in both L2 to L1 and L1 to L2 than those given in the auditory modality. Furthermore, it was observed that particularly erroneous answers were given in the L1-L2 auditory condition, which was also demonstrated by the analysis performed on the latency data.

4.1.7 Summary of the findings

The results obtained in the two analyses of variance were used to address the first three hypotheses investigated in this study. The first regarded the notion of the priming effect. It was demonstrated that the target items that were preceded by translation equivalents (1,119ms) were recognised faster by 94ms than those words that were preceded by an unrelated ones (1,213ms). However, the analysis of variance performed on the ERs did not reveal a significant difference in accuracy rates between the two types of target items (5.14% - related and 5.66% - unrelated). Nevertheless, the results presented above allow us to retain the first hypothesis. That is, a priming effect (measured in terms of RTs) was observed in the animacy decision task and it can be interpreted as providing support for the notion that the information stored at the conceptual level in the bilingual Chinese-English mental lexicon is shared.

Furthermore, the priming effect (measured in terms of RTs)[94] from L1 to L2 was strong and statistically significant (199ms), whereas in the opposite language group (L2 to L1)

[94] The pattern of results demonstrated by the main effect and the simple effect of language group on ERs also points to an asymmetry between the two language groups (L1 to L2 and L2 to L1). This asymmetry, however, has a different pattern. That is, more errors were made when the participants were requested to respond to English words, i.e. in the L1 to L2 direction than to Chinese targets in L2 to L1 language group. Nevertheless, previous language processing studies only reported the asymmetry with reference

the difference reported between the related and unrelated targets was small and not statistically significant (6ms). This pattern of results points to a priming asymmetry effect, which helps to retain the second hypothesis of this study in which it is stated that the priming asymmetry effect will be observable in the two language groups (from L1 to L2 and from L2 to L1), but will differ in strength. It will be weaker in the L2 to L1 language group, which in turn would further point to the varied strength of the interlexical connection, as exemplified by the RHM (Kroll and Stewart, 1994).

In addition, the investigation of the two language groups demonstrated that the participants responded more rapidly (1009ms) and with grater accuracy (3.5%) to the items presented in the L2 to L1 condition than to the target words in L1 to L2 (1351ms and 7.6%). This result demonstrates that when participants were requested to attend to words in Chinese they were quicker and more accurate.

To investigate the impact of the modality on language processing (third hypothesis) a comparison between the visual and auditory modalities was made. It was shown that words in the visual modality were recognised faster (by 635ms) and more accurately (by 3.3%) than those items presented in the auditory modality. In addition, the answers given in the L1 to L2 auditory condition were considerably slower (1741ms) and less accurate (10.65%) than those given in the other conditions. Furthermore, priming effects were shown in the visual (60ms) and auditory (125ms) conditions, with those in the latter seemingly stronger than those in the former. Finally, there was a facilitative effect for the related items in both modalities (visual and auditory), but it was statistically significant only in the L1 to L2 language group; the answers provided to the unrelated words in the L1 to L2 auditory condition were seemingly slower as compared to the other conditions.

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to RTs. Therefore, a decision was made to report the asymmetry only with regard to this dependent variable in the present study.

The combined findings from the two ANOVAs support the third hypothesis, which predicted that there will be a difference between the priming effect for words presented in the visual and auditory modalities, which demonstrates that the processes are not identical and that the processing of words might be modality-dependent.

All in all, the analysis of the latencies data and error rates demonstrated a priming effect. Also, evidence was found for a priming asymmetry effect as outlined by the RHM, i.e. a strong, consistent priming effect measured in terms of RTs was found from the L1 to L2 language group, but a weak effect was reported from L2 to L1. Finally, evidence was shown that items in the visual modality were recognized quicker and more accurately than in the auditory. The implications of the findings presented in this project as well as the limitations that this study approached will be discussed in chapter five. However, before this discussion is initiated the fourth hypothesis is addressed in the next section.

4.2 Analysis of data from the semantic judgement tasks

Data collected from the semantic judgement tasks was analysed with the use of the ALSCAL MDS algorithm in SPSS. The analysis allowed for the production of several conceptual maps that are presented below in the following order. First, the results obtained from all the participants who took part in the task are displayed in a single conceptual map. Then, maps produced on the basis of data collected from the bilingual participants who performed the task in English and those who completed it in Chinese are presented. Finally, two maps produced from the data obtained from the monolingual English and monolingual Chinese participants are shown. The interpretation of the conceptual relationships between terms from each individual map will be given next to the maps; whereas, information about each data matrix that was used to produce them and detailed Kruskal's Stress values are given in Appendix 15.

Kruskal's stress values is one of the methods for assessing the fit of a MDS solution (Bartholomew et al., 2002). The general guidelines for assessing fit demonstrate that stress above 0.20 indicates poor fit, 0.05 stands for good fit, and 0.00 indicates perfect fit. However, Bartholomew and colleagues (2002) also reiterated the fact that "these [the above outlined guidelines] were developed by Kruskal (1964) […] based on empirical experience rather than theoretical criteria [and therefore] these should always be used flexibly with an eye on the interpretability of the solution to which they lead" (ibid, 2002:63). Furthermore, the stress correlates negatively with the number of dimensions, i.e. it decreases when the number of dimensions is increased. As also pointed out by Bartholomew and colleagues (2002:63), "there is a trade-off between improving fit and reducing the interpretability of the solution". Three, four and more dimensional maps are increasingly more difficult to interpret and compare. Therefore, to retain the clarity of the presentations, two dimensional representations were preferred in this section of the data analysis and were used to present differences between individual maps. Three and four dimensional solutions with lower Kruskal's stress values were computed too and are enclosed in Appendix 16.

4.2.1 Similarity judgement – all participants

In order to obtain the semantic structure for all subjects, a single conceptual map was produced, based on the data collected from 67 bilingual and monolingual participants.

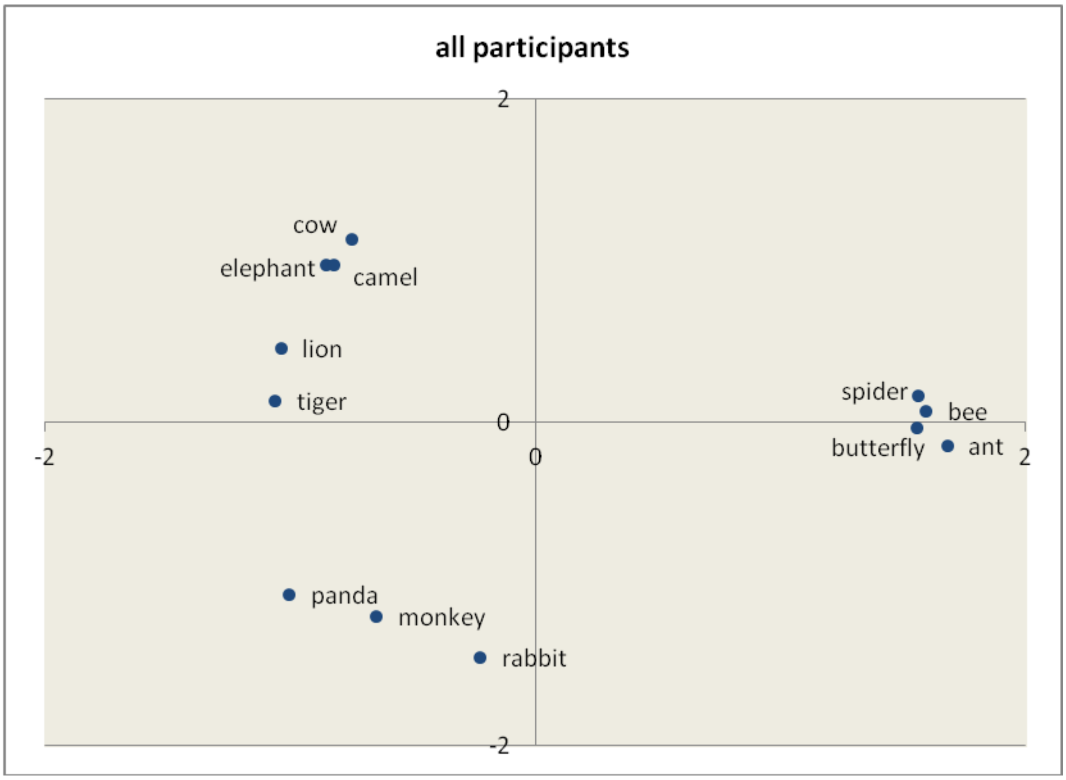

Figure 37. The semantic structures of all participants for 12 animal terms.

The map visible in Figure 37 presents an overall view of the semantic structure of 12 animal terms (*ant, cow, elephant, panda, camel, spider, bee, lion, monkey, butterfly, rabbit* and *tiger*) across 67 bilingual and monolingual subjects. The terms that are considered more similar in meaning are closer to each other than those terms that are seen/judged as less similar. For example, words such as *bee, ant, butterfly* and *spider* are regarded by the participants as closer in meaning, compared to, for example words such as *spider* and *cow* or *ant* and *rabbit*, which are much further apart from one another, as represented on the map. It can be seen how some of the data clusters close together, for instance, for words such as *cow*, *elephant* and *camel* or *lion* and *tiger*, which therefore visualises participants' similarity judgements that they gave when rating pairs of animal terms.

The multidimensional scaling analysis (MDS) not only allows for describing the structure of a semantic domain, i.e. the arrangement of the terms relative to each other, but also it helps to identify the dimensions that the participants used to judge the similarities. A two dimensional representation of the semantic structure of animals was chosen for the map in Figure 37 as well as all the other maps presented in this chapter. Dimension 1 (x axis) has been be interpreted by this researcher as representing types/categories of animals, i.e. a category of insects to the right of the 0 y axis and a category of wild and farm animals (mammals) to the left. Dimension 2 (y axis) has not been unanimously identified yet. It could be viewed as representing size within each category of animals, i.e. how big or small the real world referents of the animals are. To be able to apply this interpretation, however, it would be necessary to consider it separately within each category of animals presented on the map. It is also possible that a third or even fourth dimension may carry some additional information that is not visible in the presented structures. However, whatever the case, multi-dimensional structures are difficult to graph and interpret.

4.2.2 Similarity judgement – bilingual English and bilingual Chinese

In order to represent the semantic structure of animal terms for the bilingual participants, two separate conceptual maps were produced, one based on the ratings given in English by 18 bilingual speakers and the other Chinese based on the ratings from another 15 bilingual participants. Both maps are presented below in Figures 38 and 39.

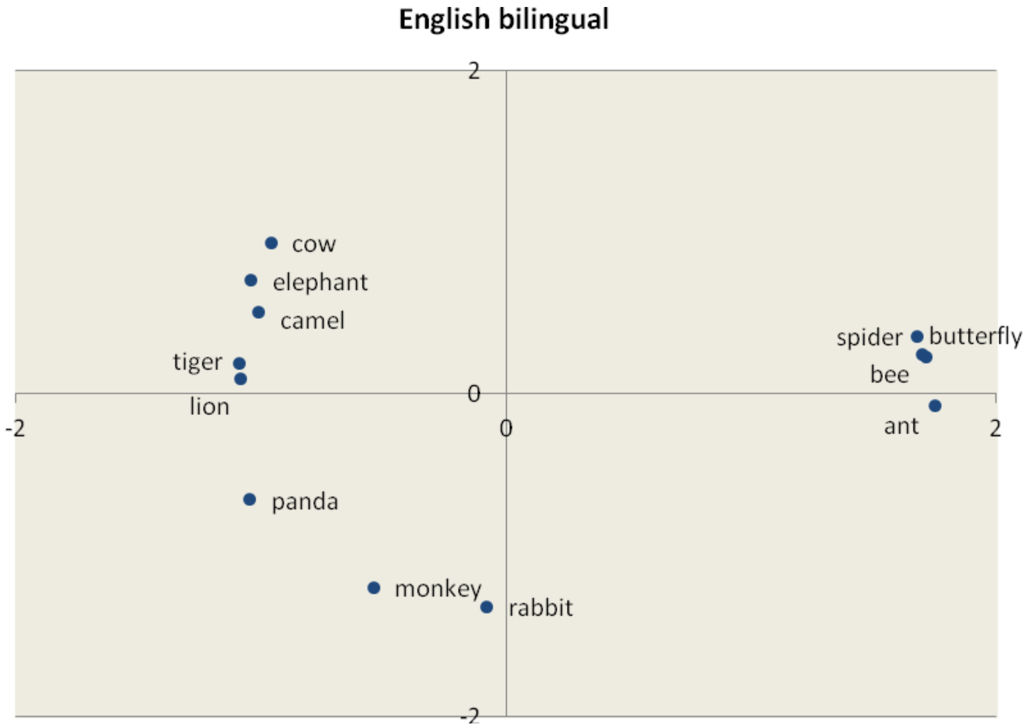

Figure 38. The semantic structures of English bilingual participants for 12 animal terms

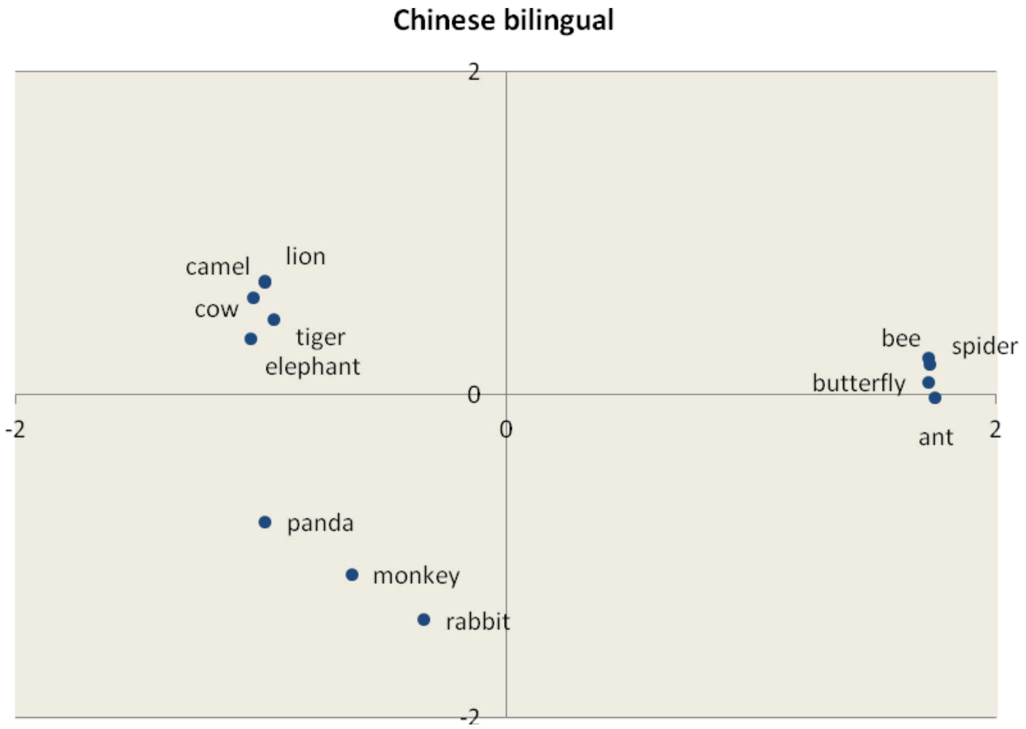

Figure 39. The semantic structures of Chinese bilingual participants for 12 animal terms (for the convenience of presentation all Chinese items were named/marked in English).

The two maps introduced above (Figure 38 and 39) have similar semantic structures. In both languages, in English and Chinese, the terms describing insects, i.e. *ant*, *bee, spider,* and *butterfly,* are clustered close together in the upper right cell. There is almost a complete overlap between the terms *bee* and *butterfly* in the English version and a partial overlap between the terms *bee* and *spider* in Chinese. Furthermore, the words *rabbit, monkey,* and *panda* are grouped together in the lower left cell and the remaining five terms *tiger, lion, camel, cow* and *elephant* are presented in the upper left cell on both maps. However, there is a slight difference in the distribution of the terms in the upper left cell on the two maps. That is the proximities of the terms to the horizontal axis are reversed, i.e. on the English map, two terms, *tiger* and *lion* are closer to the axis, whereas on the Chinese, those terms are further away from the axis, in turn, the terms referring to *cow* and *elephant*, are closer. Also, it can be observed that there is a complete overlap between two terms, *camel* and *lion*, in the Chinese version of the map.

4.2.3 Similarity judgement – monolingual English

In order to compare the semantic structure of bilingual speakers to monolingual speakers, two maps were produced based on the information obtained from the monolingual English (Figure 39) and monolingual Chinese participants (Figure 40). Here, the results collected from the monolingual English sample are described.

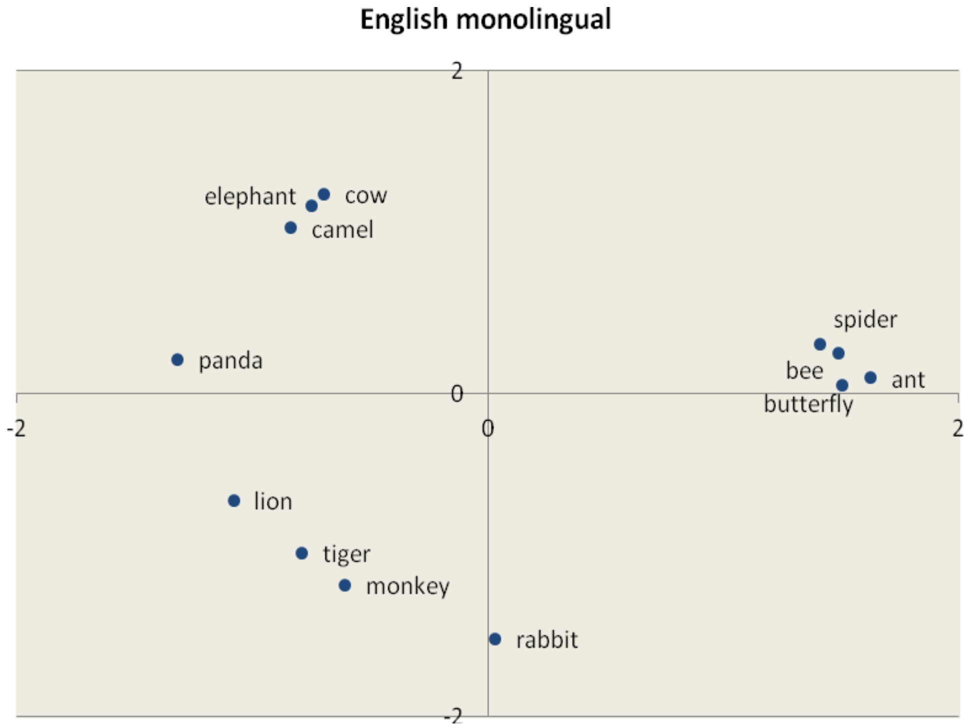

Figure 40. The semantic structures of English monolingual participants for 12 animal terms

The general outlook of the map represented in Figure 40 is similar to the bilingual maps presented in the preceding section. However, it can be observed that this map differs from the previous ones in several ways. For example, the terms referring to the insects are still grouped together, but there is a greater distribution between the terms, i.e. there is no partial or complete overlap between the terms as on the bilingual maps. Furthermore, some terms in the above structure are distributed differently to those presented in the bilingual maps, i.e. the term *panda* is in the upper left cell; the term *rabbit* is on the other side of 0 y axis, i.e. in the lower right cell, and the terms that refer to *lion* and *tiger* are presented in the lower left cell.

4.2.4 Similarity judgement – monolingual Chinese

The last of the individual maps is based on the similarity judgements collected from the Chinese monolingual participants in Beijing.

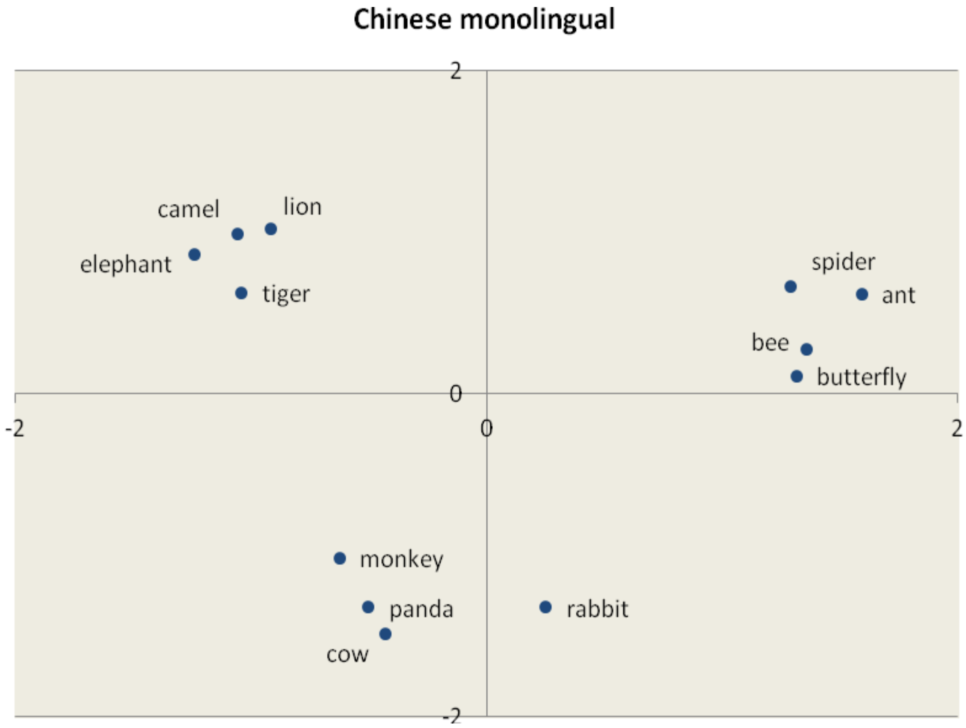

Figure 41. The semantic structures of Chinese monolingual participants for 12 animal terms (for the convenience of presentation all Chinese items were named/marked in English).

Similarly to the monolingual English map, that presented in Figure 41 differs from the semantic structures obtained for the bilingual participants. That is, the distribution of some of the terms is different, i.e. the term describing *rabbit* is in the lower right cell (similarly to the location observed in the monolingual English map). Also, the term which refers to *cow* is on the other side of horizontal axis, i.e. in the lower left cell. Finally, there seems to be a greater distribution between the terms referring to the insects.

4.2.5 Similarity judgement – comparison

To understand better the observed differences between the individual maps, the results were plotted on to three additional maps, allowing for a comparison between: (1) bilingual Chinese semantic structure and the bilingual English one; (2) bilingual Chinese and monolingual Chinese; and (3) bilingual English and the monolingual English map. The three comparisons are depicted in Figures 42, 44 and 45 below.

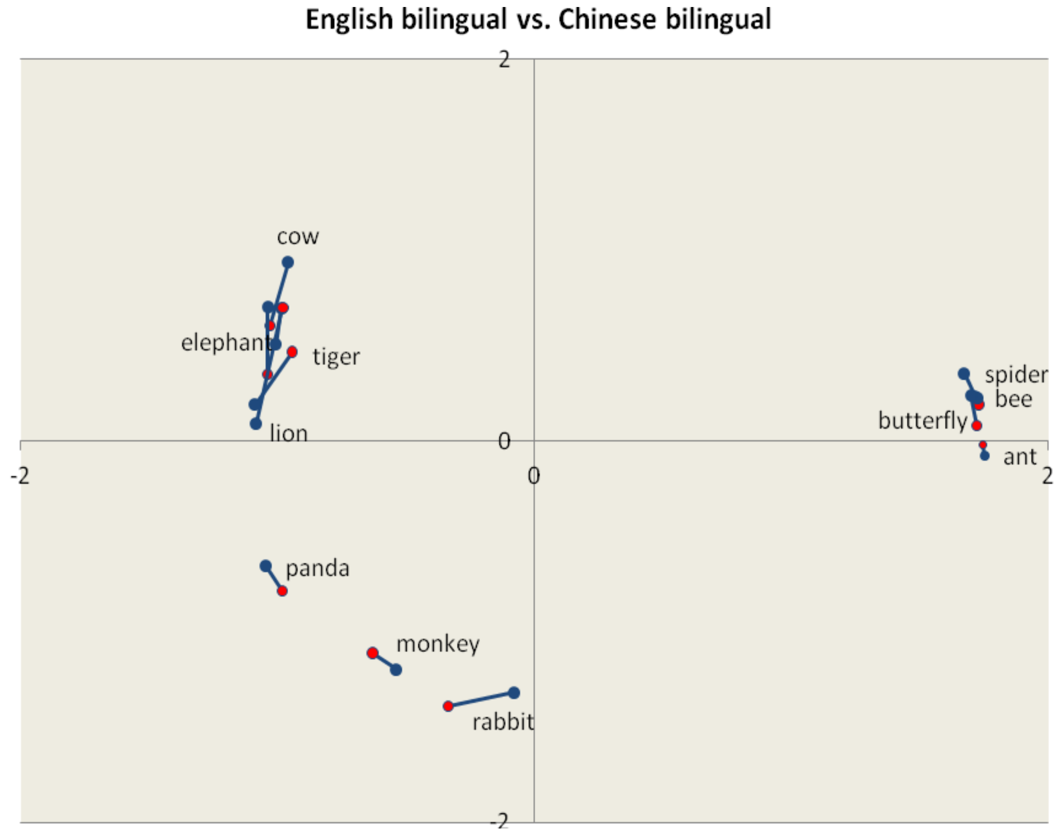

Figure 42. A comparison of the semantic structures of Chinese bilingual participants (red dots) and English bilingual speakers (blue dots) for 12 animal terms

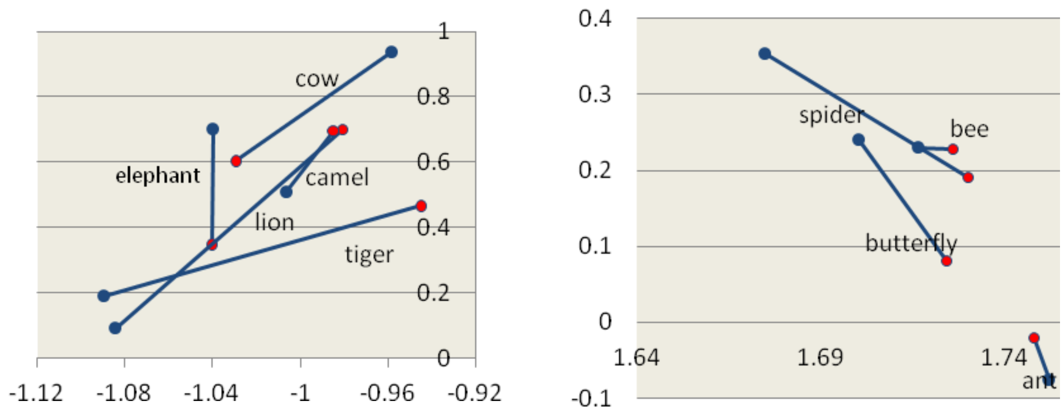

Figure 43. A close up look at the comparison of the bilingual semantic structures; upper left cell (left map), upper right cell (right map)

The animal terms presented on the bilingual Chinese-English conceptual map (Figure 42) have a very similar distribution as the distances noted between the same terms are relatively short. In the upper left and the upper right cells the terms are clustered to the extent that it is actually difficult to see the individual distributions. Therefore, these two areas were enlarged/zoomed into and are presented on two additional maps in Figure 43.

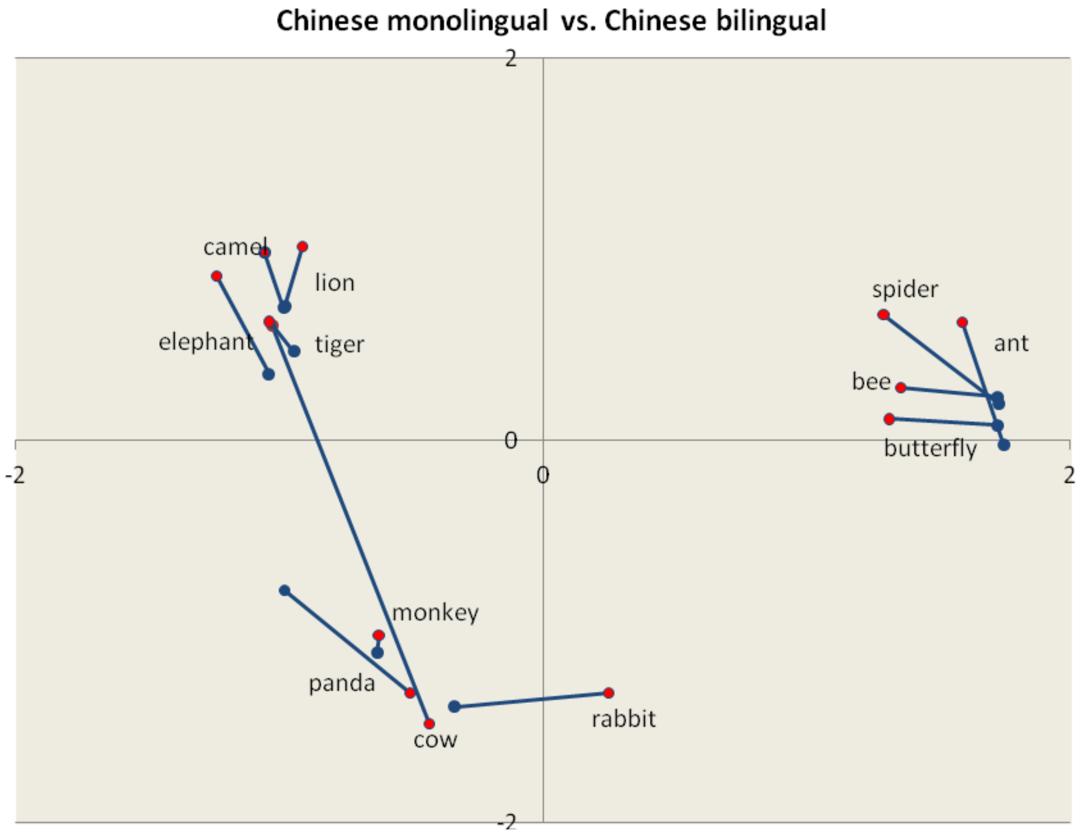

Figure 44. A comparison of the semantic structures of Chinese monolingual participants (red dots) and Chinese bilingual speakers (blue dots) for 12 animal terms.

The comparison of the semantic structure of Chinese monolingual participants and Chinese bilingual speakers (Figure 44) seems to reveal a greater degree of distribution between the animal terms than that reported on the previous semantic structure (Figure 42). That is, the distances between the individual terms are seemingly larger than those depicted on the bilingual Chinese-English map. For instance, the term 'cow' was judged by the bilingual and monolingual participants in a very different way and that is reflected in the long vector that runs across the upper and lower left cells joining both terms.

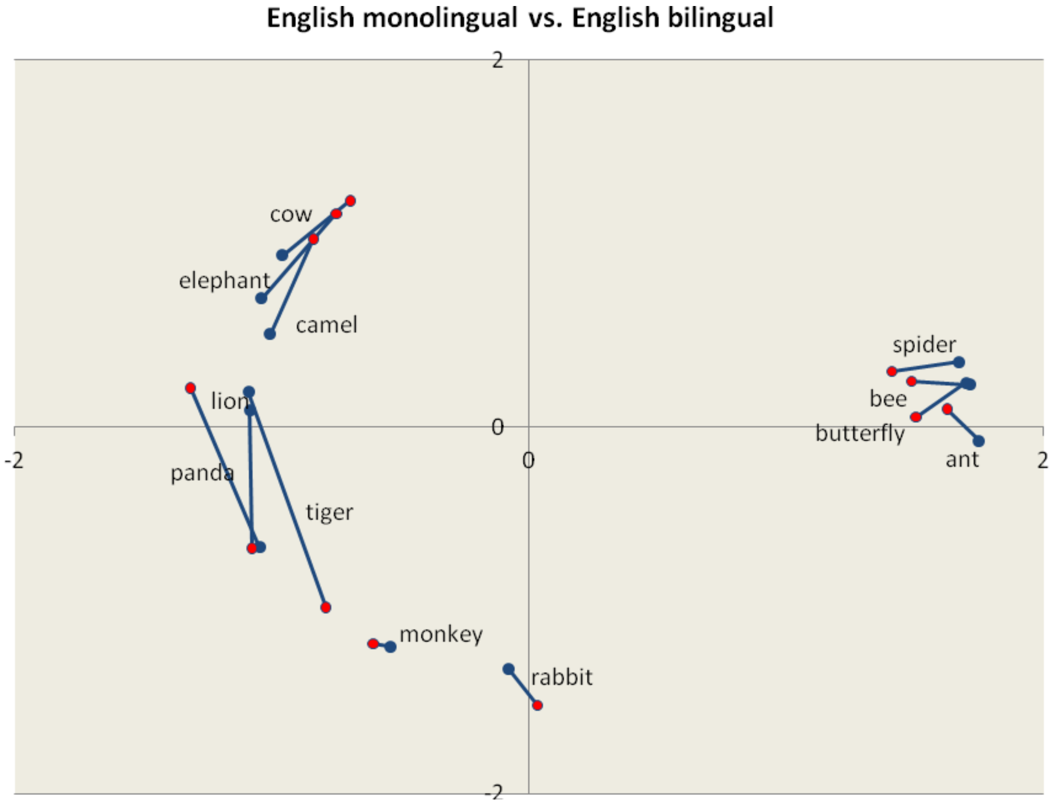

Figure 45. A comparison of the semantic structures of English monolingual participants (red dots) and English bilingual speakers (blue dots) for 12 animal terms.

Finally, the comparison presented in Figure 45, also appears to suggest a certain level of distribution between the animal terms that is not, for instance, visible in the bilingual Chinese-English map. That is, the terms are located further away from each other, which could reflect the fact that participants used a different set of judgments while evaluating the similarity of the given animal terms. For example, the differences are clearly visible between the terms: panda, lion, and tiger, which cross the horizontal axis.

To explore the difference between the distributions of the three comparisons/semantic structures, the Euclidean distances between the locations of the 12 animal terms (66 pairs) were used to calculate the average of all the distances[95]. This procedure was repeated

[95] The analysis described here followed a similar procedure utilised by Zhao and Li (2010:514-515), which they used to compare average distances on semantic maps for three L2 (English) learning conditions, i.e. simultaneous, early L2, and late L2 learning. The researchers were interested in comparing all three conditions with each other, therefore, they computed a one-way analysis of variance, which was then

three times individually for each comparative map. The results revealed that the average distance on the Chinese bilingual vs. English bilingual map was equal to 0.22875; whereas the average distance for the Chinese monolingual vs. Chinese bilingual map was 0.58393 and for the English monolingual vs. English bilingual map it had a value of 0.46901. A paired samples t-test was conducted to test the impact of the group comparison (bilingual semantic structure vs. monolingual-bilingual semantic structure) on the distance measure. The first t-test revealed that the Chinese monolingual vs. Chinese bilingual map had significantly shorter distances than the Chinese monolingual vs. Chinese bilingual map [t (11) = 2.278, $p < 0.05$] (Figure 46). Also, a significant difference in distances was shown between the Chinese monolingual vs. Chinese bilingual map and the English monolingual vs. English bilingual map [t (11) = 2.784, $p < 0.05$] (Figure 47).

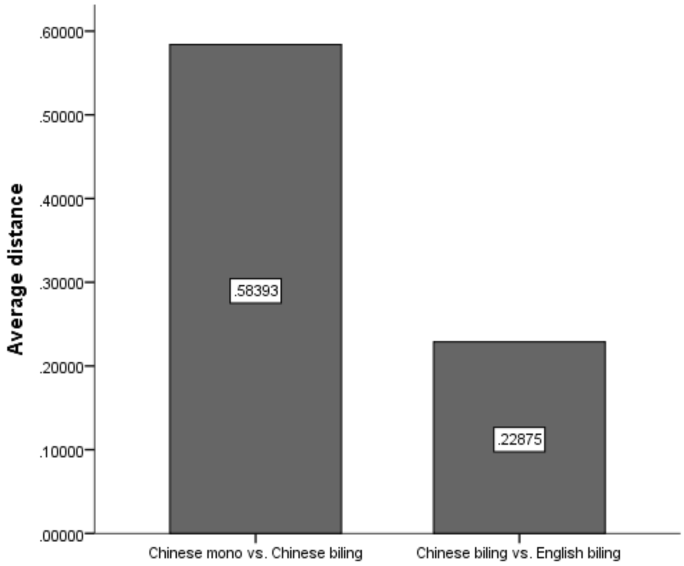

Figure 46. A comparison of the average distance on two semantic maps, i.e. Chinese monolingual vs. Chinese bilingual and Chinese bilingual vs. English bilingual.

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followed by a post-hoc Bonferroni test. Here, a decision was made to calculate a paired samples t-test as only two maps were compared with one another at a time.

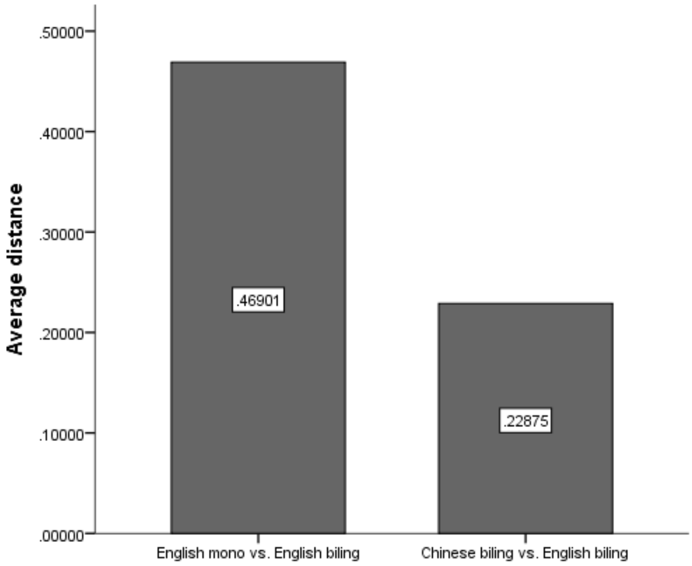

Figure 47. A comparison of the average distance on two semantic maps, i.e. English monolingual vs. English bilingual and Chinese bilingual vs. English bilingual.

To sum up, the fourth hypothesis examined in this study stated that the spatial representation of the semantic relationships will be similar for Chinese and English words, if the conceptual information is shared between the two languages in Chinese-English bilinguals. The results presented above show that there is a level of similarity between the two bilingual maps that is different in several respects from the monolingual English and monolingual Chinese maps. These findings could first of all point to the fact that a bilingual person can be seen as a unique speaker/hearer and not simply as two monolinguals in one person (Grosjean, 1989). Furthermore, they could point to a process of *semantic convergence*, i.e. a bilingual representation that is different from both monolingual representations (Ameel, 2005, 2009; Pavlenko, 1999). Both possible explanations will be addressed in detail in the next chapter.

This chapter illustrated the results obtained from the implicit priming and semantic judgement tasks administered to the bilingual and monolingual participants in this project. The results are very promising, but in order to understand them fully, they need to be further interpreted. Thus, an extensive discussion of the findings will be presented in the next chapter.

CHAPTER FIVE

DISCUSSION

An extensive discussion of the results obtained in the study is presented in this chapter. It is initiated by representing and evaluating the four hypotheses investigated in this project by means of comparison with previous research studies. The findings are discussed with reference to the model investigated in this study, i.e. the Revised Hierarchical Model (Kroll and Stewart, 1994). Also to provide a comprehensive illustration of the scope of the findings, these are also discussed with reference to a computational memory model, i.e. DevLex II. Finally, the constraints that this study faced - constraints that might have had an impact on the results obtained - are identified, discussed, and possible solutions to these limitations are put forward.

5.1 General discussion

The Revised Hierarchical Model (Kroll and Stewart, 1994) depicts the bilingual lexicon as organised on two levels, i.e. lexical and conceptual. The former level of representation comprises two separate stores, L1 and L2, one for each language; however, the conceptual level is seen as shared between the two linguistic systems. So far, the RHM has been tested mainly with reference to bilinguals who speak Indo-European languages (e.g. Dutch-English in Kroll and Stewart, 1994 or English-Spanish in Talamas et al., 1999) and there is little research that has focused on the comparison of two distinct languages, such as Chinese and English. It is likely that the distance between the two linguistic systems can 'shape' the conceptual level in bilingual speakers in a particular way. Therefore, the major aim of the present study was to investigate how concepts are stored and accessed in the bilingual lexical memory of Chinese-English speakers. It was hypothesised that it is possible for conceptual information to be shared (as demonstrated by priming effects). It was further hypothesised that: (1) bilinguals might activate more conceptual information when accessing it from L1 rather than from L2 (priming asymmetry effect), (2) bilinguals might not process the conceptual information in the same way in the visual or auditory modalities, and that (3) the bilingual semantic structures will be similar.

The priming experiments replicated a reliable priming effect. It was shown that translation equivalents were recognised quicker than unrelated words (words that do not share meaning). Also, in the L1 to L2 language group the priming effect was strong, but in the opposite language group, i.e. from L2 to L1, it failed to emerge and this pattern of results is consistent with the effect of priming asymmetry. Moreover, the experiments provided findings on priming in two modalities; a topic that has not been extensively researched in the language processing literature. The priming effect was greater in the auditory modality; however, the overall recorded reaction times were faster in the visual one. Finally, the semantic judgement task results showed that bilingual semantic structures differed slightly from the monolingual ones, which could point to the process of *semantic convergence* (e.g. Ameel et al., 2009; Ameel et al., 2005; Pavlenko, 1999). For clarity of presentation, each of the investigated elements is discussed in more detail in the four subsections below.

5.1.1 Priming effect

The first hypothesis stated that a priming effect would be observable in an implicit conceptual memory task, if the information stored at the conceptual level in the bilingual Chinese-English mental lexicon is shared. The findings obtained in the priming experiments supported this hypothesis, whereby it was demonstrated that the related items (e.g. *lǎoshī* (老师) – teacher)[96] were recognised more rapidly by the participants than the unrelated targets (e.g. *chǒngwù* (宠物) – teacher)[97]. This facilitative difference in RTs resulted in a priming effect of 94ms, which can be interpreted as evidence for the shared conceptual level of representation for the bilingual Chinese-English speakers.

The priming effect reported in this study (94ms) was quite robust. Other studies reported effects that were smaller, e.g. 33ms reported by Basnight-Brown and Altarriba (2007) or 48ms by Duyck and Warlop (2009a). The facilitative effect, in this study, might have occurred due to the nature of the task that was used, i.e. the implicit conceptual task (animacy decision task) that tapped directly into the conceptual level of representation and therefore produced a strong priming effect. However, since this study made no direct comparison between the animacy decision task and the lexical decision task, it is difficult to substantiate this claim. Nevertheless, it is also possible that the variation in the reported results between the current project and the previous studies (summarized in Table 18) might stem from a number of methodological differences of the present work. For instance, the primes in the present study were displayed for 30ms, which is 20ms shorter than the prime presentation in e.g. Jiang (1999), Jiang and Forster (2001), or Schoonbaert and colleagues (2009) and this length of time was selected to make sure that subliminal priming occurred. This duration was chosen based on the pilot study, during which some participants reported seeing primes at the display rate of 45ms, especially in the L1 to L2 condition, when the primes were shown in Mandarin Chinese. Moreover, not all of the extant studies had a blank interval of 50ms that followed the presentation of the prime, which might have resulted in an insufficient amount of time being allocated for the processing of the primes (Jiang, 1999). Also, the duration of the backward mask presentation varied (from 50ms to 150ms), which in turn resulted in different SOAs.

[96] teacher - teacher
[97] pet - teacher

Additionally, Schoonbaert and colleagues used both concrete and abstract nouns and showed that there was no significant interaction between concreteness and priming. They demonstrated, however, that using concrete nouns yields stronger cross-language priming as when compared with abstract ones. The words used in this study were all examples of concrete nouns, either animate or inanimate nouns, which may have contributed towards a stronger priming effect.

authors	**bilinguals**	**N**	**stimuli**	**n**	**prime**	**blank**	**backward mask**	**SOA**
Jiang (1999) Ex. 4 & 5	Chinese (L1) English (L2)	18	concrete	16	50	50	150	250
Jiang & Forster (2001) Ex. 1	Chinese (L1) English (L2)	26	abstract	16	50	50	150	250
Schoonbaert et al. (2009) Ex. 1 & 2	Dutch (L1) English (L2)	20	abstract concrete	26	50	50	150	250
Schoonbaert et al. (2009) Ex. 1 & 2	Dutch (L1) English (L2)	40	abstract concrete	26	50	_	50	100
Schoonbaert et al. (2009) Ex. 3 & 4	Dutch (L1) English (L2)	20	abstract concrete	26	50	50	150	250
Schoonbaert et al. (2009) Ex. 3 & 4	Dutch (L1) English (L2)	40	abstract concrete	26	50	_	50	100
present study visual	Chinese (L1) English (L2)	50	concrete	55	30	50	150	230

Table 18. Methodological variations between several priming studies (partially adapted from Schoonbaert et. al., 2009); N, number of participants per experiment; n, number of observations per condition per participant; SOA, stimulus onset asynchrony

To sum up, the priming effect observed in this study seems to be stronger in magnitude than those recorded by several previous studies. This difference might be due to the use of the animacy decision task, or the methodological variation in the design of the task. However, it is difficult to pinpoint the reason of this difference. On the whole, the priming effect observed in this research supports the statement that the way the RHM (Kroll and Stewart, 1994) captures the representation of the conceptual level is also applicable to Chinese-English bilingual speakers. The conceptual level is shared, at least for the concrete nouns/pairs of translation equivalents that represent both animate entities and inanimate things.

5.1.2 Priming asymmetry effect

The second hypothesis researched in this study stated that a priming asymmetry effect will be observable between the two language groups (from L1 to L2 and from L2 to L1), i.e. it will be greater in magnitude for the L1 to L2 language group compared with the L2 to L1 direction, if the strength of the connection between L1 and C and L2 and C differs, as outlined by the RHM (Kroll and Stewart, 1994). Based on the findings from the priming tasks the second hypothesis was retained. That is, the priming effect from L1 to L2 was substantially greater (199ms) than that reported from L2 to L1 (6ms). This asymmetry is in line with the representation account captured by the RHM (Kroll and Steward, 1994). It seems that the strength of connections between L1 level and concepts is greater than those between L2 and concepts. Hence, it might be the case that when the prime is presented in L1 more conceptual information is activated/available for processing information, which then spreads to the target and therefore a stronger priming effect can be observed (Jiang, 1999). On the other hand, in the opposite language group, when L2 prime is used a weak effect or even inhibition (a negative effect) is found in some cases (e.g. Finkbeiner et al., 2004; Jiang, 1999; Keatley et al., 1994).

The asymmetry reported in this study is not surprising. There is an overwhelming number of studies that have found a strong priming effect from L1 to L2 but a weak and inconsistent one from L2 to L1 (e.g. Gollan et al., 1997; Jiang, 1999; Jiang and Forster, 2001; Keatley et al., 1994). More recently, there have been several studies (e.g. Basnight-Brown and Altarriba, 2007; Duñabeitia et al., 2010; Duyck and Warlop, 2009b; Perea et al., 2008; Schoonbaert et al., 2009; Wang, 2013)[98] that showed a significant

[98] Basnight-Brown and Altarriba (2007:960) increased the prime presentation time to 100ms to provide a ‘‘slightly longer amount of time [for the participants] to process words in their less dominant language’’. Primes at such exposure might have become visible and hence the language processing might have not been automatic. Duñabeitia et al. (2010) conducted their study with highly proficient Spanish-Catalan, simultaneous bilinguals. In Duyck’s and Warlop (2009) study the Dutch-English participants were low proficiency, unbalanced bilinguals living in an L1 environment.

priming effect also in the L2 to L1 direction. However, the effect was still smaller in magnitude than that of L1 to L2. Duñabeitia and colleagues (2010) made a comparison of several studies and concluded that "the average effect for forward masked translation priming [L1 to L2] was 39ms, while the average effect for backward masked translation priming [L2 to L1] was only 6ms" (ibid, 2010:99). The researchers attributed the priming asymmetry effect to the fact that the reviewed studies were conducted with unbalanced, nonsimultaneous bilinguals. This finding has also been confirmed by Wang (2013) who demonstrated that the relative bilingual balance in two languages more accurate explains the priming asymmetry than for instance language proficiency alone. In this study, the participants were dominant in Mandarin Chinese and most of them acquired English sequentially to Chinese. Hence, the priming effect was reported from the dominant language (L1) to the less dominant (L2), but it was not observable in the opposite direction. Furthermore, Duyck and Warlop (2009:173) reported that "the backward translation priming effect (from L2 to L1) has only been reported in studies with bilinguals living in an L2 dominant environment". The participants who took part in the current project were living in a fairly balanced linguistic environment, i.e. they used English at university but Mandarin Chinese at home and with friends. This might be yet another reason why the priming effect was not observed with this group of participants in the L2 to L1 language group[99].

The priming asymmetry effect has been observed when same script languages are compared (e.g. Dutch-English in Duyck 2005) as well as when different script languages

[99] Symmetrical priming effects have been demonstrated by those studies that worked with balanced bilingual participants. However, since the phenomenon of balanced bilingualism is not as prevalent as dominant bilingualism (Grosjean, 1989), it is worth examining other experimental factors, such as: the design of priming tasks that might modulate the priming effect. For instance, Lupker and Davis (2009) developed a method called sandwich priming that allows for showing a priming effect with primes that are all-transposed letters. A brief presentation of the first prime, identical to a target word, helps to reduce lexical competitor effects. So far, this effect has been observed with monolingual speakers. It would be interesting, though, to investigate whether similar findings can be demonstrated when employing sandwich priming with bilinguals.

(e.g. English-Hebrew in Gollan et al., 1997) are examined. However, the effect seems less strong when the language scripts are not shared. We can read from Table 19 that the priming effects reported by, e.g. Schoonbaert et al. (2009) or Duyck and Warlop (2009), who worked with Dutch-English bilinguals, seem to be greater in magnitude than those of, e.g. Jiang (1999) or Jiang and Forster (2001), who conducted projects with Chinese-English bilingual speakers. Nonetheless, the results obtained in this study do not seem to ascribe to the same overall pattern of findings, i.e. despite the fact that two different scripts were used; the reported priming effect in L1 to L2 visual condition is seemingly greater in magnitude than those effects found in the same script studies.

authors	**bilinguals**	**N**	**stimuli**	**n**	**prime**	**blank**	**backward mask**	**SOA**	**L1-L2**	**L2-L1**
Schoonbaert et al (2009) Ex. 1 & 2	Dutch (L1) English(L2)	20	abstract concrete	26	50	50	150	250	100*	28*
Duyck & Warlop (2009)	Dutch (L1) French (L2)	24	_	11	56	_	56	112	48*	26*
Jiang (1999)	Chinese(L1) English (L2)	52	abstract	16	50	_	_	50	45*	13*
Jiang & Forster (2001) Ex. 3 & 4	Chinese(L1) English (L2)	18/24	abstract	16	50	_	_	50	41*	4
present study visual	Chinese (L1) English (L2)	50	concrete	55	30	50	150	230	199***	6

Table 19. Summary of the priming asymmetry effects partially adapted from Schoonbaert et al. (2009); N, number of participants per experiment; n, number of observations per condition per participant; SOA, stimulus onset asynchrony; $*p < 0.05$; $***p < 0.001$

The discrepancy in the priming asymmetry effect between the same script studies and different script investigations has been explained in terms of an advantage, which stems from the shared fast operating ‘machinery’ of language processing. Regarding this, Schoonbaert and colleagues (2009) and Grainger and Frenck-Mestre (1998) explained that the sublexical representations shared between primes and targets facilitate the processing of targets, when the languages are similar. This account, however, does not explain the findings that were reported in this project; therefore, an alternative interpretation had to be found. Gollan and associates (1997) proposed the *orthographic* *cue hypothesis* to explain the noncognate priming effect, which is often observed in experiments with different scripts but not in studies with same scripts. The researchers claimed that when two orthographically different languages are investigated (Hebrew and English in Gollan's et al. study), the script provides a cue that speeds up the access to a relevant lexicon, thus ensuring fast processing of the prime. The results obtained in this study are partially supportive of this account. It seems that when the scripts are different, e.g. Chinese and English, the script acts like an access cue that can determine the speed of language processing, even in a situation when the participants were not consciously aware of the bilingual nature of the priming task. To support fully the extension to Gollan's et al. hypothesis, it would be necessary to run within language priming experiments as a baseline and then compare the intralanguage behavioural effects with the interlanguage effects detected in this study.

To sum up this section, the above discussed findings support the representation account put forth by the RHM (Kroll and Stewart, 1994). That is, the priming asymmetry effect between the two language groups demonstrates that the strength of interlexical connections does indeed differ, i.e. it is stronger from L1 to C than that from L2 to C. Nonetheless, there are further questions that need to be answered before the representation account is accepted as fully conclusive. One of the questions, as indicated by Jiang (1999), is related to the locus of asymmetrical priming and the RHM model allows two options to be considered. The cross-language priming might be conceptually mediated (e.g. Kroll and Stewart, 1994; Potter et al., 1984) or can be seen as lexical in nature (e.g. de Groot and Nas, 1991; Gollan et al., 1997). This is yet an unresolved issue and according to Jiang it must be clarified if the representational explanation for asymmetry in cross-language priming is to be adopted. The locus of the priming asymmetry was not investigated in this project but it is certainly an interesting aspect to be further examined in the future.

5.1.3 Visual and auditory modality

The third element investigated in this project was the impact of modality on language processing. It was assumed that there would be a difference between the priming effects for words presented in the visual and auditory modalities, which would demonstrate that the processes are not identical and hence that the processing of words is modality-dependent. The priming effect reported for the auditory modality was equal to 125ms, whereas that for the visual modality was equal to 60ms, which confirms that the processes are not identical. Furthermore, it was demonstrated that the targets in the visual modality yielded quicker (862ms) and more accurate (3.8%) responses than those in the auditory modality (1496ms and 7.1%). This difference in response times might be attributed to the fact that "auditory stimuli cannot be recognised on the spot with the onset of stimulus presentation like visual stimuli but need to be at least partly articulated before the word can be identified" as explained by Degner (2011:1718). It is also plausible that the observed differences in reaction times (RTs) and error rates (ERs) between the two modalities might have occurred due to the specific design[100] of the visual and auditory priming experiments. To better understand the scope of findings, they are compared to other studies[101] as outlined in Table 20 below.

[100] The primes and targets were presented at different rates in the visual and auditory experiments in this study, i.e. 30ms in the visual and M=340/370ms in the auditory modality.

[101] The procedure of the auditory priming task used in this project resembled the original procedure used by Kouider and Dupoux (2005a) and Dupoux et al. (2008). However, both published studies used very complex designs, e.g. prime compression rates of 35%, 40%, 50%, and 70%. Furthermore, they varied the relationship between primes and targets. They looked at morphologically, phonologically and semantically related words and nonwords. Moreover, the primes and targets were superimposed on the mask, which was played in a form of time compressed reversed prime. Due to the complexity and methodological variations, a decision was made not to compare this study with Kouider's and Dupoux (2005b) and Dupoux et al.'s (2008) investigations but with the simpler designs that were followed by Anderson and Holcomb (1995) and Holcomb and Neville (1990).

authors	participants	N	stimuli	n	prime	backward mask	SOA	target	Priming
Anderson & Holcomb (1995) V	English	12	concrete	360	400	_	0/200/800	400	53***/ 32*/19*
Anderson & Holcomb (1995) A	English	12	concrete	360	*M*=562	_	0/200/800	*M*=568	18/57***/ 142***
Holcomb & Neville (1990) V	English	16	concrete	160	400	_	1550	400	33[a]
Holcomb & Neville (1990) A	English	16	concrete	160	*M*=400	_	1550	*M*=400	109[a]
present study V	Chinese English	50	concrete	55	30	150	230	until response	60***
present study A	Chinese English	46	concrete	55	*M*=340/370	*M*=360 /330	600	*M*=740	125***

Table 20. Summary of the priming effects in the visual and auditory modalities; N, number of participants per experiment; n, number of observations per condition per participant; SOA, stimulus onset asynchrony; V, visual modality; A, auditory modality; [a] Holcomb & Neville (1990) did not calculate the values of the priming effects. They provided mean RTs for related, unrelated words, pseudowords, and nonwords. The effects given in the table were calculated by this research based on the comparison between related and unrelated words;*p < 0.05; ***p < 0.001

Overall, the results from this study resembled those reported by Anderson and Holcomb (1995) and Holcomb and Neville (1990)[102], whereby the priming effect was greater for the auditory modality (125ms) than for the visual (60ms). Anderson and Holcomb reported priming effects of 18ms/57ms/142ms in the auditory modality and 53ms/32ms/19ms in the visual, whereas Holcomb and Neville showed 109ms facilitation in the auditory modality and 33ms effect in the visual. Despite the fact that the overall patterns of results were alike, the magnitude of the priming effects seems to differ. Once again, the effects reported in this study seem to be greater in magnitude than those of Anderson and Holcomb and Holcomb and Neville. This dissimilarity might be related to the methodological/procedural variations that can be found between the studies. Regarding this, Anderson and Holcomb and Holcomb and Neville worked with small

[102] The comparison has been made with monolingual studies as there are no other bilingual/cross-language auditory priming studies known to this researcher.

numbers of participants[103], but investigated a much larger number of stimuli compared to this project. In addition, the primes were displayed for 400ms and were not masked in these two studies, which suggest that the primes might have been visible and not subliminally processed.

Furthermore, apart from the priming effects, another interesting observation was made. It took participants longer to respond to the stimuli presented in the auditory modality than in the visual. The participants also made more mistakes in the auditory condition. In Anderson and Holcomb's investigation, participants also gave slower answers to auditory stimuli (911ms/812m/756ms to related items and 929ms/869ms/898ms to unrelated items)[104] than to visually presented words (773ms/715ms/736ms to related items and 826ms/747ms/755ms to unrelated items). The same pattern of findings was illustrated by Holcomb and Neville, i.e. 718ms mean response rate given to related items and 827ms given to unrelated items in the auditory modality and 653ms response to related and 686ms to unrelated targets in the visual. Anderson and Holcomb (1995:189) attributed these differences to two possible sources, i.e. "the availability of information over time or the attentional influences". This latter explanation however, can hold, but only partially, as the design of Anderson and Holcomb's (1995) experiments, is rather questionable. That is, they presented stimuli simultaneously at 0ms SOA, or overlapping at 200ms SOA, or sequentially at 800ms SOA. One can imagine how difficult it is to attend to a target word that is played at the same time as the prime, or when the beginning of the target is not clearly audible as the first 200ms overlaps with the last 200ms of the prime.

[103] The small number of participants in Anderson and Holcomb (1995) and Holcomb and Neville's (1990) studies was related to the design. Apart from behavioural data, they also collected ERPs.

[104] The results are presented in the following order: 0ms SOA, 200ms SOA, and 800ms SOA.

The results obtained in this project in the auditory and visual modalities varied; however, it is difficult to pinpoint whether this variation was due to a true effect or difference in the task design. The cross-language auditory priming task used in this project is a new paradigm and hence, it should be viewed more as an exploratory technique[105] rather than one providing conclusive findings. The results should therefore be treated with caution.

To conclude this part, the collected findings do substantiate the claim made by Holcomb and Neville (1990) that auditory and visual word recognition do not rely on the same processes of memory. We know that language processing is highly interactive across modalities and that "phonological information influences written word processing and orthographic information influences auditory word processing" (Van Orden and Goldinger, 1994 in Marian 2009:62). Nonetheless, it seems that the processes (visual and auditory language processing) are not identical and that the information in the two modalities might become available at slightly different rates. However, the nature of this difference needs to be explored further and it can be done by applying a more constrained experimental design, which is discussed in subsection 5.2.2.2 of this chapter.

5.1.4 Degree of semantic overlap

The majority of psycholinguistic investigations that tackle the issue of the bilingual language processing with the use of priming paradigm 'adjourn their enquires' when the priming effect is shown in a cross language condition. That is, priming effects are seen as sufficient proof for the shared level of representation. However, in this project, I was motivated to take the understanding of the conceptual level of representation a step further and hence the decision was made to investigate the level of semantic overlap, specifically the spatial representation of the semantic relationships. It was assumed that

[105] The limitations of comparing both visual and auditory domains directly are discussed in subsection 5.2.2.2 of this chapter.

the spatial representations would be similar for Chinese and English words (specifically for the animal terms), if the conceptual information is shared between the two languages in Chinese-English bilinguals. Since the priming task does not allow for addressing the content of the conceptual store (Pavlenko, 2009), a semantic judgement task was selected to gain better understanding of this level of representation.

A comparison between the bilingual and monolingual semantic maps revealed that the bilingual English and Chinese maps differed from the monolingual English and Chinese ones in several respects. The distribution of the items (animal terms) on the maps seemed not the same, which suggests that the bilingual participants viewed the items in a slightly different way from the monolingual participants. Furthermore, the semantic structures of the bilingual English and Chinese had a level of similarity, which can be interpreted as demonstrating that the conceptual information is shared. These findings imply two things. First, a bilingual person should be seen as a unique speaker/hearer and not simply as two monolinguals in one person (Grosjean, 1989). Second, it is likely that the long-term interaction between L1 and L2 leads to certain conceptual modifications[106], e.g. the process of *semantic convergence* (e.g. Ameel et al., 2009; Ameel et al., 2005; Pavlenko, 1999). Pavlenko (1999:223) explained that this refers to a process where "a unitary system is created, distinct both from L1 and L2". The convergence may take place due to a parallel activation of both languages, and more specifically due to a process called *retrieval-induced reconsolidation* (Wolff and Ventura, 2009). This describes a situation when "a memory trace can become temporarily labile and susceptible to change after

[106] According to Pavlenko (2000b:3) a *conceptual change* can demonstrate itself as (1) *internalization* of new concepts, (2) *shift* from an L1 to an L2 conceptual domain, (3) *convergence* of concepts into a separate domain different from those of L1 and L2, (4) *restructuring* during which new concepts are incorporated into existing ones, (5) *attrition*, a gradual weakening of concepts that are not used, often associated with *substitution* of old concepts by new ones. These changes resemble the impact of the L1 on L2, the influence of L2 on L1, or an interaction between the two systems. The notions of a conceptual change and language interaction were not investigated in this project, but it seems likely that the process of semantic convergence can shed light on the findings obtained from the semantic judgement task.

reactivation by a different memory trace" (Ameel et al., 2009:272). The participants in the current study used both of their languages on a daily basis and hence it is likely that "encounters in each language may reactivate the other language frequently, resulting in labile memory traces that are susceptible to cross-linguistic interference in both directions", as put by Ameel and colleagues (2009:272). This in turn can then result in a somewhat intermediate system different from both monolingual ones. To put it in Grosjean's words (1989:6), "the bilingual is […] a unique and specific speaker-hearer, […] [who] has developed competencies (in the two languages and possibly in a third system that is a combination of the first two) to the extent required by his or her needs and those of the environment". Nonetheless, this claim cannot be fully supported by the findings obtained in this study since only a small number of prototypical animal terms was used in the semantic judgement task. To explore the nature of the semantic convergence in a greater detail, more comprehensive similarity ratings would need to be collected including: other semantic domains[107] and terms that are more language/culture specific[108]. The modifications that should be introduced to the semantic judgement task will be further discussed in subsection 5.2.3 of this chapter.

5.1.5 Models

The findings presented in this study can substantiate the theoretical predications of the RHM (Kroll and Stewart, 1994) in their original form. That is, evidence was found for both a shared conceptual level of representation (priming effect in both the visual and auditory modalities) as well as for the differing strengths of interlexical connections (priming asymmetry effect). Nevertheless, it has to be noted that only one class of words, i.e. concrete nouns were investigated in this study. It is likely, therefore, that the model

[107] Other investigated semantic domains, for instance, have included: colours (Moore et al., 2000), emotions (Romney et al., 1997) and kinship terms (Romney et al., 1995).

[108] In case of the Chinese participants, names of Chinese zodiac animals could be an interesting area of research.

could be presented differently, if other classes of words were considered, e.g. abstract nouns or verbs. For instance in this regard, Jiang (1999) and Jiang and Forster (2001), who worked with Chinese-English bilinguals, demonstrated that the priming effect for abstract nouns is not consistent. Jiang (1999) used high frequency abstract nouns and showed priming effects of 45ms (L1 to L2) and 13ms (L2 to L1). Also, Jiang and Forster (2001), who also used abstract nouns demonstrated a priming effect of 41ms but only in the L1 to L2 direction and the effects of 4ms and 8ms in the L2 to L1 language order were not statistically significant. In addition, it seems that even the assumption about closely corresponding meanings of concrete nouns across languages is not correct (Malt and Ameel, 2011). These authors showed that French-Dutch speakers name and sort common household objects differently, which could reflect the differing linguistic and cultural histories of the languages (ibid).

Furthermore, it is also plausible that the conceptual store are depicted by the RHM (Kroll and Stewart, 1994) could be presented differently, i.e. in a more distributed form, if another type of task has been administered. For instance, if a narrative elicitation task (e.g. Pavlenko, 2002) was used instead of a priming task, the experiments could have yielded a different pattern of results. As described in Chapter 2, Section 2.2.1.3, when examples from other disciplines of research, such as cognitive linguistics or cognitive psychology are considered, it is easy to notice that there are: (1) words that do not have translation equivalents; (2) words that do not have conceptual equivalents; (3) words that retain language/culture specific denotations and connotations; and (4) words with referents that are culture specific (Jared et al., 2013). These examples may suggest a more distributed conceptual level of representation. Therefore, this researcher regards the RHM model with its slightly modified conceptual level (as represented in Figures 6A and 6B) to be a conceivable framework, but one that has not been empirically verified in this study.

To understand better the scope of findings obtained in this study, a decision was made to also discuss them with reference to a computational model, i.e. DevLex-II (Zhao and Li, 2010). This model is preferred over other computational models, e.g. BIA (Dijkstra and van Heuven, 1998) or BIA + (van Heuven and Dijkstra, 2010), as it has been trained on two languages of interest to this thesis, i.e. Chinese and English. Also, it is more dynamic than other computational networks, i.e. it has a learning mechanism, which allows for simulation of different histories of language learning, e.g. simultaneous vs. consecutive. In addition, as explained by Zhao and Li (2013:289), "the model incorporates a computational mechanism for simulating spreading activation based on the distance of bilingual words in the semantic space". DevLex-II (Figure 48) is an unsupervised neural network model that includes three levels, i.e. the core/feature map that manages the semantic/conceptual representations and it is connected to another two feature maps, one for input phonology and one for output phonology (Li, Zhao, McWhinney, 2007). It has been used to simulated both the priming effect and priming asymmetry effect, specifically, Zhao and Li (2013) implemented it to simulate both translation and semantic priming across Chinese and English under two conditions, i.e. early vs. late L2 learning.

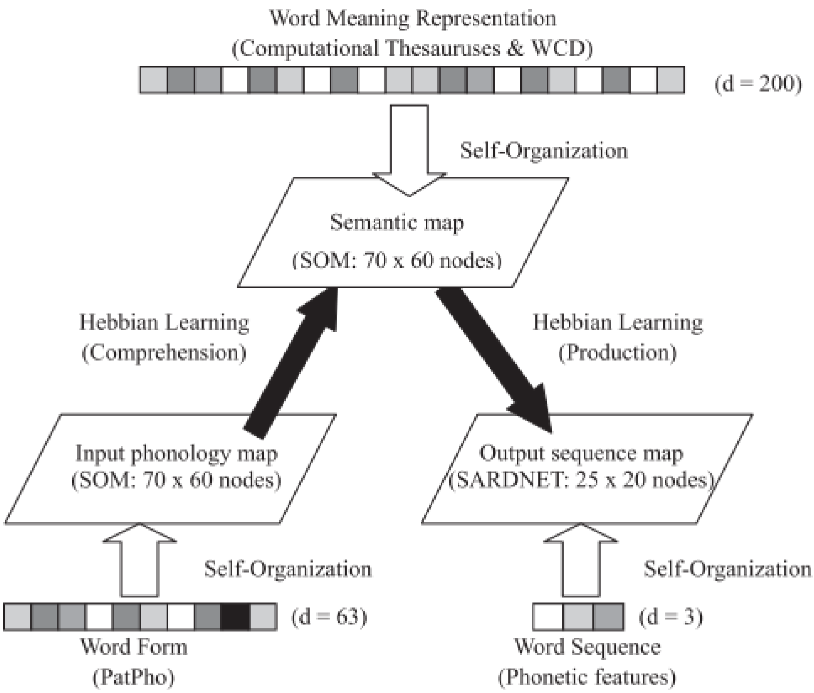

Figure 48. DevLex-II model (Zhao and Li, 2013:290)

In the experiment conducted by Zhao and Li (2013), the network learned Chinese as L1 and English as L2, also different learning histories were simulated, i.e. words in both languages were presented to the network at different intervals, with a significant lag for late L2 learning. It was demonstrated that the data generated by the model was consistent with several previous psycholinguistic studies (e.g. Basnight-Brown and Altarriba, 2007; Schoonbaert et al., 2009). That is, a stronger priming effect was observed from L1 to L2 than in the opposite language order, i.e. L2 to L1. Also, the translation priming effect was stronger than the semantic priming one. Finally, the priming effect was stronger in magnitude for late learners than that for the early ones. The last finding was explained by Zhao and Li (2013) as resulting from fairly equal levels of proficiency in both languages and similar amounts of spreading activation taking place across both languages (ibid, 2013:299).

The priming asymmetry effect observed in this study is consistent with the one simulated by DevLex-II. Here, the asymmetry was explained in terms of the differing strength of connections between L1 and concepts and L2 and concepts, as represented by the RHM (Kroll and Stewart, 1994). Zhao and Li (2013), on the other hand, put forward an interesting alternative to the understanding of the priming asymmetry. According to these researchers, bilinguals might have a richer semantic representation or better understanding of words in L1 as compared to L2. Therefore, there is less confusion or lexical competition between lexical items in that language. However, since "L2 items are represented in more densely populated neighbourhoods and hence have increased lexical competition from their nearby lexical items" (ibid, 2013:301), this may lead to insufficient level of activation (when presented as primes) that will then spread to target words. Furthermore, similarly to the findings presented in this study, Zhao and Li (2013) also observed that bilinguals respond quicker to target words presented in L1 rather than L2. Here, this difference was attributed to the participants' language dominance in Chinese. However, Zhao and Li (2013) offered an interesting account based on the representation of words in the bilingual lexicon rather than on the participants' level of proficiency. That is, these researchers explained that L2 words are more densely distributed and therefore there is more lexical competition taking place between different L2 lexical items, which, in turn, leads to overall slower reaction times in L2 in an LDT. DevLex II offers useful and insightful explanations with regard to the priming effect and the priming asymmetry effect that have not been considered by other psycholinguistic models and this, yet again, endorses the importance of interdisciplinary work.

To conclude this section, both the Revised Hierarchical Model (Kroll and Stewart, 1994) as well as DevLex II (Li, Zhao, McWhinney, 2007) have their strengths, they allow for posing of new questions and formulating new hypotheses; however they also face certain limitations. Hence, they should be seen as transitional ones (Pavlenko, 2009). Kroll and Tokowicz (2005:531) have advocated that memory models need to be able to account for "distinctions between levels of language representations, differences in components of processing associated with unique task goals in comprehension versus production, and the consequences of the developmental aspect of language experience". This statement should be treated as guidance for developing new models that will act as hypothesis generators and as roadmaps (Brysbaert and Duyck, 2010) that will aid further our understanding of the bilingual lexical memory's organization and processing.

5.2 Limitations

This study faced several limitations which might have had an impact on the presented findings. The limitations were related to the selection of the bilingual and monolingual participants, the constraints related to the use of the implicit priming paradigm, and the use of the semantic judgement task. Each of the identified limitations is separately addressed below and certain feasible solutions are offered.

5.2.1 Selection of participants

The bilingual and monolingual participants were chosen carefully for this project and from an initial group of 165 that were screened, data from 130 was used in the final analysis. This procedure was followed in order to assure homogeneity of the samples. Nevertheless, the recruitment of participants was subject to certain limitations.

5.2.1.1 Selection of bilingual participants

In this study, all bilingual participants were asked to fill in a comprehensive questionnaire that apart from biographical information included language preference section and language proficiency evaluation. The questionnaire was designed following

Grosjean's suggestion (1998) about the information[109] that experimental psycholinguistic studies should report regarding their participants. The information obtained from the questionnaire was analysed (with factor analysis) and used to choose only those participants that met the selection criteria, i.e. bilingual Chinese-English speakers, between the ages of 18 to 25, right-handed, and dominant in Mandarin Chinese. Even though careful measures were taken in order to select a uniform group of bilingual participants for this study, it was difficult to control for several other factors which could have introduced variability in the obtained results. For instance, during the experimental session it was difficult to ensure that the participants were in a monolingual mode (Grosjean, 1989). That is, all participants were greeted in English and the spoken instructions were also given in English, but about half of them were asked to perform a Chinese priming task. Nevertheless, it seems that the issue of interaction with an L1 or L2 speaking researcher during an experimental session should not be too much of a concern. Athanasopoulos (2011) varied the experimental setting, i.e. some bilinguals were instructed in L1 (Japanese) and some others in L2 (English) on the same tasks, and showed that the results did not differ. As a consequence, the researcher commented that "perhaps simply varying the experimenter and the language of instructions is not sufficient to introduce the relevant language mode" (2007:46).

In addition, some participants who were described as bilingual could speak more than two languages/dialects, and as a matter of fact they should be more accurately described as trilingual, quadrilingual, or to put it simply multilingual. Knowing a third or fourth language may introduce additional modifications to the architecture of the mental lexicon. However, for the time being this is only speculation as there are no known studies to this

[109] According to Grosjean (1998:135), the information should include: biographical data (age, sex, education level); language history (age and context of language acquisition); language stability (developing language skills); function of languages (purpose and context of language use); language proficiency (proficiency in four language skills); and language mode (amount of time spent in the monolingual and bilingual modes).

researcher that have investigated the conceptual representation of trilingual or multilingual speakers[110] and this area of study is certainly an interesting avenue for future research.

In order to overcome the limitations approached during the recruitment of the participants, i.e. to control for the language mode during the experimental session, the researcher could have chosen to address them only in the language of the priming task. For instance, if they were to respond to Chinese targets, then may be they should have been greeted in Chinese, and the instructions as well as the biographical questionnaire should also have been given in Chinese. However, to be able to exercise this type of experimental procedure, additional resources would have been needed in order to translate the questionnaire into Chinese and a fluent Chinese speaking research assistant would have been needed to help with the data collection.

5.2.1.2 Selection of monolingual participants

The monolingual English and Chinese participants were chosen as controls for the semantic judgement task. Since the focus of this study was on the student population and since English is taught at most higher education institutions in China, it was difficult to ensure that the monolingual Chinese participants had no knowledge of English or other foreign languages. As a matter of fact, most of the Chinese participants indicated being able to use English to a limited degree mostly in academic contexts. Nonetheless, for the purpose of this study they were treated as monolingual, which is a common practise in the field of psycholinguistics. For instance, Ameel and colleagues (2009) who worked with monolingual French and Dutch speakers explained that “although the monolingual participants had some knowledge of the other language through formal instruction at

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[110] de Groot and Hoeks (1995) worked with Dutch-English-French trilinguals and investigated the impact of foreign language proficiency on the processing routes, i.e. word association and concept mediation.

school, they did not consider themselves proficient in it and considered themselves to have one native language" (ibid, 2009:275). Also, Athanasopoulos (2011) referred to their Japanese monolingual participants as 'functional monolinguals', i.e. individuals with minimal English proficiency. The same principle was applied to the monolingual English participants who were selected for this project. That is, they reported being able to use some Indo-European languages, but on a basic level and on occasions, such as visiting other countries or speaking with foreign friends. It is not surprising that finding 'true' monolinguals, i.e. those individuals that are incapable of speaking nothing but their native language, proves more challenging in today's highly interconnected world. As put forth by Pavlenko (2011:3), "in today's globalized urban environment, it is more and more difficult to locate monolingual speakers of languages other than English" and as demonstrated in this project, finding monolingual English speakers in a university in a metropolitan centre like London is difficult. Therefore, in order to be able to locate 'true' monolinguals, most likely the study would need to change focus to less well educated inhabitants from the provinces, but even then how can one guarantee that participants do not know some formulaic phrases of other neighbouring languages/dialects?

In order to control more thoroughly for the Chinese participants' ability to speak other languages, an English language test could have been added to the biographical questionnaire. Subsequently, the participants with the lowest scores would have been included in the project, but yet again this procedure would involve designing additional research tools (i.e. language test) and gaining access to much larger groups of monolingual speakers. Moreover, it would not be possible to administer such a test to the English speakers as they indicated being able to speak several different languages, such as: French, Spanish, and Portuguese. Designing three separate tests would be too time consuming and not feasible for a project of this scale.

5.2.2 Priming task

A masked primed animacy decision task has not been extensively used before to examine bilingual language processing, with the only two other known studies that administered such a task being those by Li and colleagues (2009), and Zeelenberg and Pecher (2003)[111], for most other studies have relied on the primed lexical decision task. Also, the cross-language auditory task was probably the first one to be used with Chinese-English bilinguals and the constraints that these designs faced are discussed next.

5.2.2.1 Primed animacy decision task

Several previous studies (e.g. Durgunoglu and Roediger, 1987; Li et al., 2009; Zeelenberg and Pecher, 2003) have provided empirical evidence that varying task retrieval demands[112] produce distinct results. Since the conceptual level of information was of interest in this project, careful steps were taken to select a task that would ensure processing of the semantic information rather than the orthographic or phonological features of the presented stimuli. Regarding this, the participants had to rely on deep processing (Francis et al., 2010a), i.e. they had to retrieve the semantic content before they were able to reach a decision about items in an animacy decision task. If they had relied on the shallow processing, most likely, they would have provided erroneous answers. In other words, without knowing the meaning of the word *spider* or *kettle* it was not possible to make a correct and informed decision about the animacy status of the word.

Apart from ensuring that the task was *conceptually-driven*, it was necessary to make sure that it was implicit in nature so as to enable automatic language processing and to

[111] Zeelenberg and Pecher and Li et al. used two phase design (study phase and test phase) paradigms. In this type of design the priming effect is not measured as the magnitude of the difference between related and unrelated items but between studied and non-studied items.

[112] Durgunoglu and Roediger (1987) distinguished between *data-driven* and *conceptually-driven* tasks. Zeelenberg and Pecher (2003) differentiated between *conceptual* and *conceptual* tasks.

eliminate the use of translation strategies and processes, such as: *the expectancy* and *semantic-matching strategies* (Neely, 1991; Neely et al., 1989). To achieve this objective, a highly constrained experimental design was followed, whereby the primes were displayed for 30ms in the visual condition and were time compressed by 50% in the auditory. Also, a very short SOA and forward as well as backward masks were introduced to prevent the participants from consciously perceiving the primes (following Basnight-Brown and Altarriba (2007) and Schoonbaert's et al. (2009) suggestions). This design and the use of the primed animacy decision task helped in the observation of a robust priming effect. However, the interpretation of the latency data obtained from the priming task has to be made with caution. Conventionally, in psycholinguistics faster RTs are seen as being indicative of stronger *interlingual connections*[113], which in turn are attributed to shared meanings (Pavlenko, 2009). As further stated by Pavlenko (2009:129) "reaction-based tasks, developed for the study of language processing, are well-suited for examining the strength of interlingual connections, but do not offer us any means to examine the contents of linguistic categories and thus to determine the degree to which they are actually shared". The reaction-time-based tasks were not developed to address the relationship between words and real-world referents but simply between word forms (ibid, 2009:130).

Even though the latency data in this study was interpreted according to the traditional psycholinguistic approach, this researcher acknowledges the restrictions of a priming task. Certainly, priming tasks can tell us a lot about the speed with which words are processed in within and cross-language conditions, but to address the content of the conceptual store and the degree of semantic overlap, other more suited tasks have to be used. For instance, in this study a semantic judgement task was chosen to investigate the

[113] Interlingual connections are connections between word forms (Pavlenko, 2009).

degree of overlap of the conceptual store. Pavlenko (2009) argued that cross-cultural research methods, e.g. naming tasks, categorization and sorting tasks and narrative elicitation tasks[114] , are more appropriate for investigating the content of the conceptual store. These paradigms have higher ecological validity and are more sensitive to cross-linguistic differences than psycholinguistic research methods[115]. Hence, more attention should be paid to them and the findings that they generate before conclusions are reached about the representation of bilinguals' two languages in memory.

5.2.2.2 Auditory cross-language priming

The auditory priming task is a very promising paradigm. As stated by Degner (2011:1712) "[it] can enhance our understanding of online speech processing allowing one to tap into the acoustic mode of speech processing which cannot be achieved by relying on visual stimulus presentation only". It is also a technique that allows for working with less literate groups, such as: children, people with language impairment, and students of other languages with low levels of proficiency. By extension, cross-language auditory priming can provide a lot of noteworthy findings. However, in order to use the cross-language auditory paradigm to its fullest potential a number of modifications need to be introduced. First of all, the duration of the primes needs to be adjusted. As shown by Kouider and Dupoux (2005), the most robust subliminal priming effects can be observed when the primes are time compressed to 70% of the original duration (normal speech rate). Second, the type of mask has to be chosen carefully. It should resemble conversational noise or speech-like noise and most likely should be played continuously with the primes and targets being superimposed onto it, as presented in Figure 49 below (Dupoux et al., 2008; Kouider and Dupoux, 2005). In this way, the

[114] A narrative elicitation task involves retelling a story that the participants have read, heard, or inferred from pictures or video clips (Pavlenko, 2009).

[115] The ecological validity of psycholinguistic findings and the way of increasing this validity with the use of sentential priming and cross-cultural research methods is discussed in chapter six, section 6.1.

experiment would appear more as a natural conversational situation (a gathering or a party-like situation) where from background noise, one can decipher emerging snippets of conversation, i.e. the target words during the experiment. This procedure should increase the ecological validity of the task.

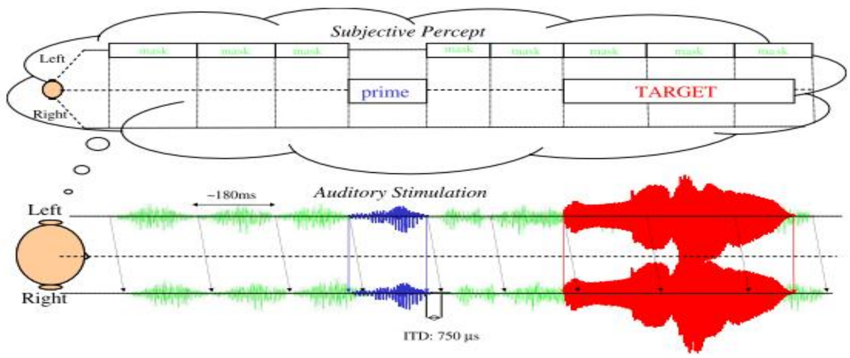

Figure 49. Diagram of the stimulus presentation in the supraliminal experiment. The mask is played in a stream and the prime is inserted in place of one mask (Dupoux et al., 2008).

It is important to verify whether tone, accent or the choice of female and male voices can influence the processing. Also, the findings from within language priming should be compared with those from cross-language priming across both modalities (visual and auditory). For instance, in this study the responses recorded in the visual modality were quicker and more accurate than those in the auditory modality. However, it is difficult to tell if this difference can be attributed to a specific effect, i.e. difference in the processing speed between the modalities or a difference resulting from the specific design of the visual and auditory tasks. That is, the duration of primes and masks differed in the two modalities. In the visual task, a 30ms prime and 150ms backward mask presentation was employed, whereas, in the auditory modality, primes were played for a mean duration of 340ms (English primes) and 370ms (Chinese primes), which were then followed by 360ms or 330ms of white noise. Furthermore, participants' responses were recorded from the onset of the target words; however, auditorily presented targets were played for a mean duration of 680ms (English targets) and 740ms (Chinese targets), whereas those presented in the visual task were displayed on the screen for a maximum duration of

2500ms or a participant's response. If auditorily presented words in the bilingual lexicon are activated in a cohort style (e.g. Marian and Spivey, 2003a, 2003b) (Figure 50) and the disambiguation of a given word takes place only after a second or third phoneme is heard (as demonstrated by the Marslen-Wilson Cohort Model, 1987), this result in overall slower reaction times in the auditory modality compared to those noted in the visual modality. This limitation could have been overcome by measuring the RTs by, e.g. introducing a delayed response procedure similar to that used by Balota and Chumbley, (1985) where participants provided their answers when prompted to do so.

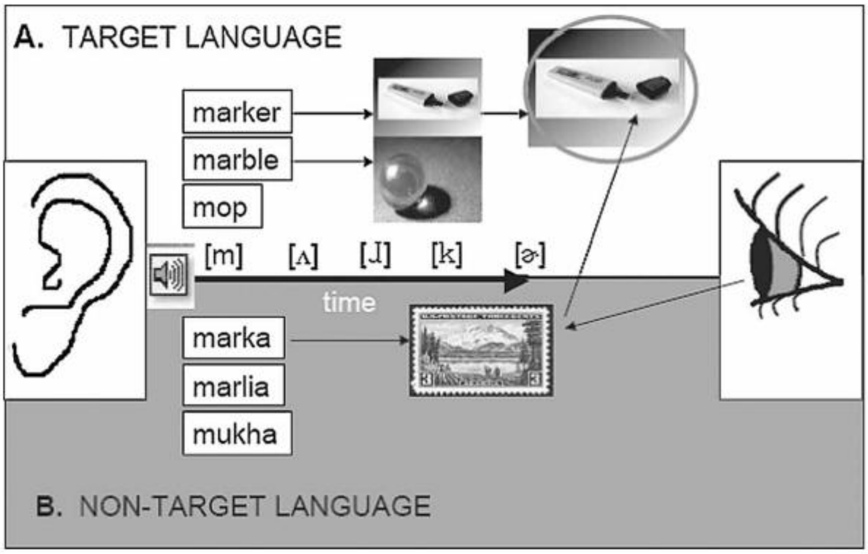

Figure 50. Graphical representation of the way in which the acoustic signal unfolds within and across languages (Blumenfeld and Marian, 2007:635)

Finally, due to the differences in stimuli presentation in the two modalities, the observed priming effects could have been influenced too. Kouider and Dupoux (2001), while investigating subliminal priming, manipulated prime duration across three groups at 33, 50, and 67ms and demonstrated that the priming effect becomes larger in magnitude with increased prime presentation. They showed statistically significant priming effects of 39, 63, and 70ms using within-modal words and 4, 17 and a significant 61ms priming effect using cross-modal words. The same pattern of results was shown by Zhao and Li (2013) with the use of the computational model, DevLex-II. Figure 51 demonstrates that at reduced SOA, both the priming effects as well as priming asymmetry effects were smaller compared to those for a longer SOA. Therefore, the comparison of the priming effects between the visual and auditory conditions in this study should be treated with caution.

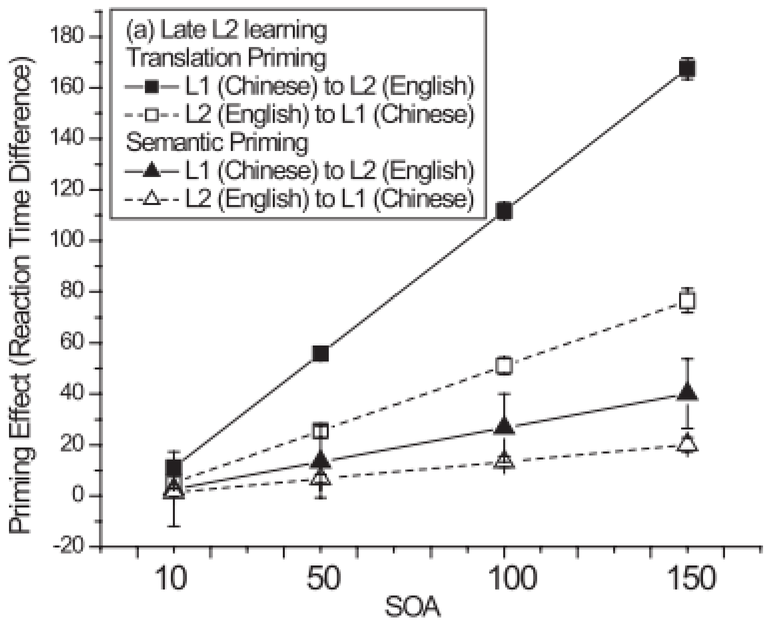

Figure 51. Priming effects at 10, 50, 100, and 150ms SOA (Zhao and Li, 2013:298)

5.2.3 Semantic judgement task

Shoben (1983:486) indicated that as a general rule of thumb, no less than nine or 10 stimuli should be used in a two-dimensional scaling. In this project 12 items were used in the semantic judgement task. However, it seems that the number of items might have not been sufficient to evaluate the semantic overlap in detail and in order to ensure higher face validity of the task, it should have been conducted in several stages. First, a group of participants should have been asked to generate/provide e.g. 20 common exemplars to the category of animals. Subsequently, the most commonly occurring animal terms should have been selected for the semantic judgement task. Next, another group of participants should have been asked to verify the chosen terms and how well they fitted the category of animals. Finally, the semantic judgement task should then have been designed and administered to participants. This would have been a much longer process, but it would have ensured that a more reliable tool was used to investigate the semantic domain of animals.

Nevertheless, the appropriateness of investigating the semantic domain of animals with bilingual speakers remains questionable. Animal terms are not represented on a continuum, unlike for instance household objects or containers that were investigated by e.g. Ameel and associates (2009; 2005). Therefore, the way in which speakers of different languages or bilinguals perceive and/or conceptualise the differences and similarities between various animals might be too small to detect. To receive a more comprehensive picture of the semantic structures, other domains, e.g. emotions or colours could have been examined. For example, a task in which colours were investigated could have been slightly more appropriate since Chinese speakers have lexical items to describe colours, such as: green jade (bluish green) (碧; bì), azure (literally, sky blue) (天蓝色; tiānlánsè), or dust/powder (粉; fěn), which, for instance, when combined with ‘red’ results in the colour ‘pink’, i.e. powdered red (粉红色; fěnhóngsè). The investigation of colours could have allowed for drawing conclusions similar to those presented by Athanasopoulos (2009), who demonstrated that Greek-English bilinguals diverge from their L1 distinction between light blue (ghalazio) and dark blue (ble) with increased exposure to L2 language use and culture.

This chapter has presented a comprehensive discussion of the findings obtained in this study. The priming effect, the priming asymmetry effect, and the semantic overlap outcomes have allowed for the level of verification of the Revised Hierarchical Model to be assessed. Furthermore, the limitations that this study approach incorporated were acknowledged and ways of overcoming them were proposed. The next chapter addresses the ways for increasing the ecological validity of the psycholinguistic findings and discusses the pedagogical implications of the psycholinguistic data/models for second language learning education.

CHAPTER SIX

IMPLICATIONS

In this chapter, two aspects are focused upon: methodological improvements and educational implications of memory models. An organizational framework for research in the mental lexicon (Libben and Jarema, 2002) is presented as a possible way of increasing the consistency in psycholinguistic investigations. Also, the ecological validity of the psycholinguistic data is discussed and several ways to increase this are proposed, e.g. the use of sentential priming and cross-cultural methods alongside psycholinguistic paradigms. Furthermore, the implications of the psycholinguistic findings for second language learning (SLL) are considered, in particular, the applicability of the RHM (Kroll and Stewart, 1994) to the educational context.

6.1 Methodological improvements

After more than fifty years of research, it is still not conclusive if two languages in a bilingual lexical memory are stored together or separately. As demonstrated in this study, the meanings of concrete nouns are shared for Chinese-English bilinguals; however, there are a lot of additional findings from the fields of cognitive linguistics and cognitive psychology (outlined in chapter two, subsection 2.2.1.3) that provide support for a more distributed conceptual store. Nevertheless, it has been suggested that the contradictory findings reported in the field may not necessarily account for differing cognitive processes being measured. That is, the conflicting situation might have been the result of the use of different terminology, different methodology, different analysis and the study of different participants (Grosjean, 1998). Indeed, Francis (1999) has stressed the fact that, in the field of bilingualism, there is a lot of confusion around the use of terminology.

Often, different terms are used to describe the same state or, worse, the same terms describe opposing notions. Expressions such as *conceptual representation* and *semantic representation* are confused. *Lexicon* is sometimes understood as a linguistic system and at other times as a specific level of representation. Francis (1999:193) has compared this situation to the story of the Tower of Babel by mentioning that “researchers may be lacking a common language” in talking about various elements of bilingualism. To exemplify this point, Francis (1999) compared various terms that are used to describe the degree of language integration in bilinguals (Table 21). Clearly, such a plethora of terms makes the comparison of research studies difficult and at times also ambiguous. If support is provided for, e.g. dual-coding theory, it is difficult to interpret it. Thus, it is important to use terminology in an explicit manner, to indicate which terms are used interchangeably, and to define clearly the studied elements.

shared process of representation	**separate process of representation**
compound	Coordinate
single store model	two store model
single-code theory	dual-code theory
dual-coding theory	dual-coding theory
language interdependence	language independence
language independence	language dependence
language generality	language specificity
language independence/generality	language dependence/specificity

Table 21. Pairs of terms used to describe the degree of bilingual language integration (adapted from Francis, 1999).

To decrease the number of contradictory findings in the field of bilingualism, it is crucial to use terminology explicitly, to carefully control factors that may introduce variability in the recruited participant sample, and to use appropriate tasks that measure given levels of representation. Another way to promote consistency of findings while researching bilingualism is to follow the organizational framework for research in the mental lexicon proposed by Libben and Jarema (2002) and discussed below.

6.2 Organizational framework for research in the mental lexicon

Libben and Jarema (2002) put forward the organizational framework for research in the mental lexicon (Figure 52) and suggested that the perimeter of the framework should be explored in order to reach the centre of the representation. Regarding this, the centre of the framework presents the main goal of research in the mental lexicon domain, i.e. “the fine-grained integrated understanding of the commonalities and diversities in human lexical ability, as well as an understanding of how that ability is neurologically instantiated and organized to interface with other components of language and cognitive processing” (ibid, 2002:8).

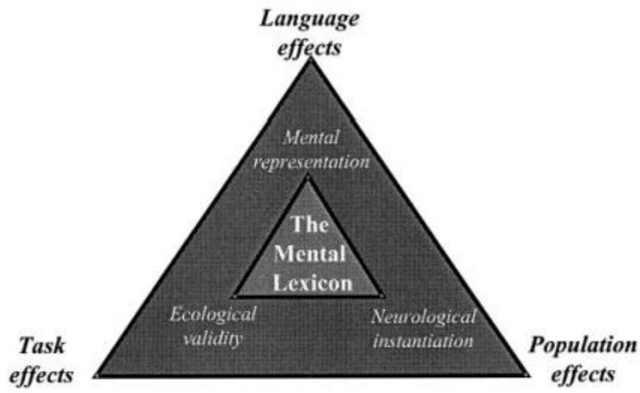

Figure 52. An organizational framework for research in the mental lexicon (Libben and Jarema, 2002)

The middle level of the framework which contains *mental representation, ecological validity,* and *neurological instantiation* presents a way in which understanding of the mental lexicon can be accomplished. Libben and Jarema explained that mental representations are metaphors that allow us to hypothesise about how lexical knowledge is acquired, organized, and/or manifested in language breakdown (e.g. attrition). Neurological investigations draws focus to understanding of the localization of the mental lexicon in the brain and the neurophysiological activation of various brain areas. Finally, ecological validity refers to understanding of the mental lexicon in terms of the role that lexical knowledge plays in a real world performance. Furthermore, the researchers considered language, population and task to be the main factors that influence the way in which research on the mental lexicon is carried out. They explained that the morphological, phonological, and orthographic characteristics of different languages make particular demands on language processing. Moreover, the population from which samples are recruited, e.g. bilingual speakers or speakers of English as a second language clearly influence the research design and the results obtained. Finally, the administered tasks can address various aspects of language processing and representation and can yield different results. They explained that “all our experimental insights into lexical representation and processing are mediated by the methodologies that we employ” (ibid, 2002:8). Therefore, the key effects (language, population, and task) need to be documented in detail.

The theoretical propositions outlined by the framework carry a very important message. The investigation of mental representations should not be done in isolation from the other two components, i.e. neurological instantiation and ecological validity. The way these representations are demonstrated neurologically and the role they play in the real world should be integrated into psycholinguistic studies to obtain a more comprehensive picture of the mental lexicon. In recent years, more cooperation between psycholinguists and neurolinguists has been observed and the integration of behavioural and neurophysiological measures can be seen too (e.g. Marian et al., 2003; Thierry and Wu, 2007). Nevertheless, it seems that little attention has been paid to the ecological validity of data collected in the laboratory settings, which should be the major target of every psycholinguistic investigation. The results of laboratory controlled experiments should be generalised to the way people communicate in a natural environment. Memory models should be applied to the type of instruction given in e.g. second language learning (SLL) classroom. In addition, the field has to be able to communicate findings to a wider audience or otherwise, the impact of psycholinguistic investigations will remain marginal.

The proposed framework and meta-analysis[116] conducted by Libben and Jarema draw our attention to another crucial aspect, whereby many of the psycholinguistic studies on the mental lexicon show a preference to focus on a particular language, population, or certain tasks. For instance, the great majority of research reported nowadays involves English language and the populations of interest are often unimpaired adult native speakers, with the most commonly chosen task being a lexical decision task. This has led to a particular view of the mental lexicon, a skewed picture in Pavlenko's words (2009). Consequently, in order to be able to verify many of the findings obtained in the field, it is necessary to (1) show how a particular task produces different results under different circumstances, and (2) to provide explicit comparisons of within and across different languages, population studies and tasks used (Libben and Jarema, 2002). Investigations involving less popular languages, varied populations and more sophisticated experimental techniques (e.g. magnetoencephalography[117], near infrared spectroscopy[118], transcranial magnetic stimulation[119]) should provide new insights into the understanding of the mental lexicon. Moreover, the organizational framework for research proposed by Libben and Jarema should be used as a guideline for future psycholinguistic

[116] The meta-analysis comprised 58 articles that were included in the special issue of *Brain and Language* [81, 2–11 (2002)].
[117] Magnetoencephalography (MEG) is a non-invasive brain scan method that maps the brain activity by recording magnetic fields.
[118] Near infrared spectroscopy (NIRS) is a non-invasive method that measures cerebral hemodynamic activity in the brain. As explained by Petitto and Funbar (2004:6) it is "portable, child-friendly, tolerates some movement, and can be used with alert babies".
[119] Transcranial magnetic stimulation (TMS) is a non-invasive method that uses electromagnetic induction to activate specific parts of the brain.

investigations. The metaphor of mental lexicon visually represented in the form of boxes, circles, and links needs to be grounded in neurophysiological evidence and examination of natural human communication to ensure that “these few strokes and dashes [do not] do injustice to the complexity of reality [but] parsimoniously capture the essence of it” (de Groot, 1992:389).

6.3 Ecological validity of psycholinguistic findings

Empirical research conducted in the laboratory has a number of advantages. For example, several chosen independent variables can be controlled and manipulated in a desired way and at the same time potentially confounding variables can be eliminated. The researcher also has control over the amount of instruction, training and participants’ responses, which is not possible in a natural environment (e.g. in an SLL classroom). Yang and Givon (1997:175) listed three advantages of examining second language acquisition (SLA) in a controlled environment: “(1) the ability to draw causal inferences by manipulating an independent variable and then examining the effects on a dependent variable; (2) the ability to replicate results; (3) the ability to select a limited number of variables for study”. Furthermore, Jiang (2004:428) indicated that “the use of reaction times provides a powerful tool for studying intangible L2 knowledge representation by uncovering in learners' observable behaviour subtle differences that are often hard to discern with other methods. This approach also allows better control of intervening variables than classroom-based research. Its findings are usually more consistent and replicable”. Nevertheless, because often laboratory research “deliberately abstracts away from real-life learning situations, it simultaneously limits the possibilities to extrapolate their findings legitimately to real-life learning” as indicated by Hulstijn (1997:132). For instance, it rarely happens in real life that we are involved in a task that involves the understanding of the individual words presented without any additional context. More often, we are exposed to strings of words in the form of print or speech. Therefore, it can be argued that many psycholinguistic experiments do not resemble actual language use and hence their ecological validity[120] is low. For instance, Pavlenko (2011) expressed her concern about the design constraints of psycholinguistic studies. According to her, experimental studies can give us a lot of information about the speed with which one can decide, whether a presented cluster of letters is a word or a non-word, but such tasks give us little information about the way the words are used in the real world. Furthermore, due to the use of decontextualised words and single pictures of prototypical objects, the picture of the bilingual lexicon that we have nowadays might be rather skewed (Pavlenko, 2009:130).

6.3.1 Ways to increase ecological validity

To increase the ecological validity of psycholinguistic findings and to be able to talk about the implications of laboratory research for education, several suggestions are put forward in this section. First, the focus is on sentential priming. Then, attention is paid to cross-cultural methods, i.e. a narrative elicitation task, a naming and sorting task, and autobiographic writings by bilinguals, used to examine the bilingual lexical memory.

6.3.1.1 Sentential priming

The sentential priming paradigm[121], which is often used to study ambiguous words, might be considered as a good alternative to a translation or semantic priming task. In this paradigm, words are presented not in isolation but in the context of a sentence. In one form, participants are required to listen to recorded sentences that contain primes, but respond to visually presented targets. The targets are displayed at the offset of a

[120] The Psychology Glossary (http://www.alleydog.com) defines ecological validity as “the degree to which the behaviours observed […] in a study reflect the behaviours that actually occur in natural settings. In addition, ecological validity is associated with generalisability. Essentially, it is the extent to which findings (from a study) can be generalised (or extended) to the real world”.

[121] The sentential priming paradigm is also known as cross-modal semantic priming.

prime embedded in the sentence or with a slight delay. Tabossi (1996:573) listed four advantages of cross-modal semantic priming: “1. It relies on a robust phenomenon (semantic priming). 2. It taps semantic activation produced by spoken stimuli on-line. 3. There is little interference with the on-going process of comprehension by the task(s). 4. It is very accurate time-wise”. However, the researcher also acknowledged certain constraints that this task faces. For instance, priming of a visually presented target is used to provide information about an auditorily presented prime and this is rather controversial as the two processes are not identical. Also, one has to exercise a lot of caution when constructing the experimental stimuli (sentences), for the individual words preceding the prime cannot be semantically related to the target, if a true priming effect is to be observed. Nevertheless, sentential priming has higher ecological validity than, for example, translation priming, because words are presented in a context that resembles natural communication, however, this has certain implications for the lexical access. It can narrow down the scope of meaning and aid quicker access to the required items. For instance, Williams (1988) indicated that a single word, e.g. a concrete noun can activate a wide range of knowledge about its shape, size, function, etc. However, all this vastness of information does not become available whenever the word is approached. That is, words are usually presented in context and it is the surrounding context that constrains access only to the relevant meaning.

Furthermore, it has been observed that a translation or semantic priming task can yield different results to a sentential priming task. For example, Swinney and colleagues (1979) and Seidenberg and associates (1982, both cited in Williams, 1988) provided evidence that the word ‘bugs’ presented in isolation in auditory form primes the word ‘ant’ and this effect is still observable when the word ‘bugs’ is preceded by a sentence which points to the meaning related to *spy*. However, the prime and the target have to be shown at a very short interval, for when the presentation of the target is delayed by about 200ms the meaning of the word ‘bugs’ is disambiguated and only priming related to the meaning of *spy* is visible. Also, Williams (1988) demonstrated that words in isolation prime related targets but the effect is not visible when the same words are presented in context. These results are attributed to a specific functional relationship between primes and targets (e.g. key-door, needle-thread) and activation of background knowledge during the comprehension of a sentence. Therefore, data from translation and semantic priming tasks should be taken as evidence for particular representation of the conceptual level of information, but to understand how we access meaning in a natural language use, sentential priming paradigm should be preferred as the task can easily be adapted to cross language translation priming. The sentences could be presented, e.g. in auditory format in Chinese, but the words displayed on the screen should be in English. The cross-language, cross-modal priming paradigm could provide important data on accessing meaning in context in both languages, on language processing in visual and auditory modalities, and on parallel activation of both languages.

6.3.1.2 Cross-cultural methods

Cross-cultural methods, e.g. a naming task, a categorization and sorting task, and a narrative elicitation task can be seen as yet another option to the paradigms commonly used in psycholinguistics. For example, Pavlenko has often relied on the last type of paradigm in her own investigations (e.g. Pavlenko, 2002, 2003). She considers narrative elicitation to be a context based task, which allows for incorporating external reality into empirical investigation (Pavlenko, 2011). Moreover, this paradigm permits the studying of spontaneous lexical choices in a controlled environment and gives a good insight into the relationship between words and their real world referents. Participants in a narrative elicitation task are requested to retell a story that they have read, heard, or inferred from pictures or video clips[122]. They respond not to directly visible referents but to previously seen referents remembered at the time of retelling (as in real life communication). This type of task has many advantages but it only allows for investigation of third person descriptions. This shortfall can, however, be overcome by post-experiment questions that elicit more referents included in the story (Pavlenko, 2011). A narrative elicitation task was used by Pavlenko (2002), for instance, to examine the way in which Russian-English bilinguals perceive their emotional states in the two languages. The participants were asked to watch two short movies in which an upset woman left an apartment after a friend of hers read her private letter. The analysis of the collected narratives illustrated that the bilinguals transformed their conceptualizations of emotions and internalised new concepts and scripts in the process of second language socialization. Furthermore, it was demonstrated that they tried to abandon the conceptualization of emotions as an active process (common to Russian) and adapt to that of a state (common to English). This depth of findings could never be obtained with a priming paradigm.

A slightly different approach to the study of concepts and their real world referents was adapted by Malt and Ameel (2011) and Ameel and colleagues (2009, 2005). Based on the assumption that the nouns for human-made objects do not correspond neatly across languages, the researchers conducted studies in which participants were asked to name and sort a variety of containers (bottles, dishes, cups). During the naming task, the participants were required to name stimuli presented on pictures, whereas during the sorting task, they were asked to sort pictures of containers according to a given quality (e.g. physical features or functional features). These paradigms are simple to design and administer and they also have high ecological validity. As indicated by Malt and

[122] According to Pavlenko (2011:205) video clips have an advantage over pictures as “they recreate an authentic external reality; they also make the story less artificial and more ‘adult-like’ and thus, more similar to spontaneous narratives.”

colleagues (1999), in the real world people connect objects with words and they also recognize properties of objects and connect them with entities stored in their memories. Ameel and associates used the naming and sorting task with Dutch-English and Dutch-French participants and observed that “bilinguals seem to incorporate some exemplars of categories of each language into roughly corresponding categories of the other language as well, resulting in a higher overlap of corresponding categories in their two languages, and hence, in more similar category centres” [123] (ibid, 2009:278). In general, they demonstrated that the bilingual naming patterns converge to a common naming pattern that is different from that of monolinguals and the convergence might take place due to cognitive economy or a *retrieval induced reconsolidation*[124] (Wolff and Ventura, 2009).

Yet another interesting method that could be applied to the study of the bilingual mental lexicon is the analysis of autobiographic writing by bilingual speakers. There are many published personal accounts, e.g. by Eva Hoffman (1998), of emigrating to another country, gaining a new identity and finding a sense of self in a new linguistic and cultural context. This method has not been extensively explored before. It is a measure that relies on a subjective account of a bilingual person but it could shed light on the nuances of e.g. language change, which cannot be observed in the controlled environment of a psycholinguistic laboratory. Autobiographic writing could be adapted into the form of a language diary and used in longitudinal studies that, e.g. document the subjective experience of language/vocabulary acquisition, reconstruction of meaning, or L1 attrition in the context of relocation to an L2 speaking country. For instance, Pavlenko (2011) seems to be in favour of this method and went as far as creating a corpus of bilingual autobiographic writing in four languages (English, French, Spanish, and Russian).

[123] “Category centres are calculated as the average or median of all the exemplars in the category […] [they] are mainly determined by high frequency exemplars of the category” (Ameel et al., 2009:273). On the other hand, category boundaries are determined by a low frequency, atypical exemplar of the category.
[124] The notion was discussed in detail in chapter five, subsection 5.1.4.

Moreover, she expressed her acknowledgement of the value of bilingual self-reports by siding with Haiman's words: "from a scientific point of view, using native testimonials is perhaps like 'making an elephant a professor of zoology', but it may be that on this kind of subject 'elephants' who do not pretend to transcend their species are more reliable authorities than 'human professors of zoology' who delude themselves that they are able to transcend theirs. To put this another way, the inner self is a subject that can be approached only from within" (Haiman, 2005:114-115 in Pavlenko, 2011:10). The analysis of autobiographic writing and the use of language diaries are certainly worth exploring further in order to observe the dynamic nature of bilingualism and the continuous impact of L1 on L2 and vice versa.

All in all, the cross cultural methods have higher ecological validity and can give insights into the aspects of mental lexicon that cannot be investigated with the use of reaction-time based paradigms. However, both approaches (psycholinguistic and cross-cultural) are valid and should be used hand in hand to provide a comprehensive picture of the bilingual lexical memory.

6.4 Educational implications

Little attention in the psycholinguistic literature has been paid to the implication of language processing findings to the educational context. That is, the various models of the bilingual lexical memory have not been translated into e.g. second language leaning[125]. In general, psycholinguists have focused on carrying out research rather than using the results to inform education. This situation might have arisen due to the scope of findings available, the inconsistencies between the findings, and difficulties in interpreting them uniformly. In the last twenty years, many different lexical memory

[125] The second language learning term is used in this thesis interchangeably with L2 learning/instruction and foreign language (FL) learning/instruction.

frameworks have been proposed e.g. the Distributed Feature Model (de Groot, 1990's), the RHM (Kroll and Stewart, 1994), the Sense Model (Finkbeiner et al., 2004), the SAM (Dong et al., 2005), and the MHM (Pavlenko, 2009) and all of these (apart from the MHM) have been empirically verified. There are certain similarities between them, e.g. they are hierarchically organized lexical and conceptual levels of representation. However, the structures differ too, especially when it comes to the theoretical assumptions regarding the conceptual level, i.e. the RHM claims that the conceptual level is a fully overlapping store, whereas the remaining models claim some level of distribution. Despite the fact that it is difficult to make any conclusive remarks regarding the bilingual lexical memory structure and its applicability to educational context, this researcher decided to deal with the 'messiness of bilingualism' (Pavlenko, 2011) and consider several possible scenarios of how the RHM (Kroll and Stewart, 1994) could inform education.

6.4.1 Applicability of the RHM to SLL instruction

If we accept the RHM with its slight modification at the conceptual level (chapter two, Figure 6A and 6B) to be correct, it is possible to consider several aspects of its applicability to SLL instruction, e.g. (1) teaching/learning vocabulary that shares or partially shares concepts between the L1 and L2, (2) teaching/learning vocabulary that has language/culture specific meaning, (3) strengthening the interlexical link between L2 and concepts to reduce mediation through L1. Each of these aspects is addressed in turn below.

6.4.1.1 Teaching vocabulary that shares concepts between L1 and L2

In principle, to learn vocabulary that shares concepts between L1 and L2 one could rely on paired-associate learning (Malt and Ameel, 2011). This means that, e.g. a Chinese learner of English would need to make simple associations between L1 and L2 such as *zhuōzi* (桌子) = *table* and *píngguǒ* (苹果) = *apple*. This view is supported to some degree by Jiang (2000:50), who explained that "in first language development, the task of vocabulary acquisition is to understand and acquire the meaning as well as other properties of the word. In tutored L2 acquisition, the task of vocabulary acquisition is primary to remember the word". Paired-associate learning can be successful, but it can only be applied to a small set of prototypical terms because, as demonstrated by Malt and Ameel (2011), the meanings of concrete nouns (common household artifacts) do not correspond closely across languages. Additionally, Sonaiya (1991:275) stated that "[…] a pair of conceptually identical languages have not yet been shown to exist" and hence learning word meaning in L2 does not only consist of rote learning/memorisation of names (labels) that can be matched with already existing concepts in L1. That is, the process of vocabulary acquisition involves ongoing refining of meaning and readjustment of boundaries between already acquired and new lexical items (Sonaiya, 1991) or as Pavlenko (2011:199) puts it, L2 learning is dynamic and "constitutes a process of re-naming the world". Therefore, paired-associate learning may not be sufficient to turn learners' attention to all the nuances of particular lexical items.

Based on the notion of *conceptual equivalence* Pavlenko (2009) advocated use of different language teaching methods. The researcher proposed that in the case of *conceptual equivalence*, L2 production tasks, translation from L1 to L2, recall of L2 words, and metaphoric extensions of given words should be used in order to strengthen the links between L2 words and their L1 translation equivalents. In the case of *partial (non)equivalence*, she suggested using tasks that would highlight the areas of similarities and differences. Exercises such as: naming, sorting, and categorization should help students to understand the native-like usage and in general aid conceptual restructuring to take place.

Similarly, Jiang (2000) divided words into three categories depending on the degree of semantic overlap. He differentiated between: *real friends, false friends* and *strangers.* The first term, *real friends* describes words in L2 that have a high degree of semantic overlap with their translation equivalents in L1, whereas *false friends* refers to words that have a translation equivalent but the degree of meaning overlap is not extensive. *Strangers*[126], in turn, refer to those terms in L2 that do not have translation equivalents, in other words, whose concepts are language/culture specific. In Jiang's opinion real friends should be fairly easy to learn as they can rely on the 'walking stick' of L1 translations. To put it differently, the semantic content is readily available in L1 and it can be copied into the L2 lexical entry. When it comes to the false friends, Jiang contended that the process of noticing a semantic mismatch is very important as it is the first stage in creating new semantic content that is specific to L2 words. He used the example of the English word *support* to clarify this point. The translation equivalent *zhīchí (*支持) is only used in the abstract form in Chinese, i.e. in a sentence such as *'I support you being elected'.* In English however, the word *support* is also used in a concrete or physical sense as in the following sentence *'We need something to support the wall'*. These differences in usage motivate students to pay attention to the context and the specificity of words. To sum up, Jiang (2004) stressed the importance of using vocabulary instruction techniques that draw students attention to semantic similarities and differences between words in L1 and L2. He suggested using explicit instruction and contrastive analysis to help learners better understand the meaning of words.

Furthermore, Jullian (2000) observed that words might have specific meanings or different semantic loads and devised an activity to help students gain word meaning awareness. The proposed task can be organized into several stages and it draws learners'

[126] The notion of *strangers* as well as *conceptual non-equivalence* is dealt with in the next section of this chapter.

attention to the full semantic content of a given word. The task consists of working with dictionary definitions and making associations between semantically related items. It starts with the selection of a leading word followed by the collection of a lexical set, i.e. other related words. For example, a lexical set for the leading word *hit* would contain words such as: *strike, beat, batter, knock, bang, punch,* etc. Once a lexical set has been prepared, students are required to perform several activities with it, e.g. (1) to classify the words according to given attributes (e.g. words that describe hitting accidentally or deliberately, or hitting with a part of the body); (2) to create a semantic word map around the leading word (an example of such a network is given in Figure 53); (3) to use the words in context (e.g. finding collocations, using illustrative sentences or unconventional sentences, providing metaphorical extensions); (4) to conduct individual research on selected words and to provide findings to the classroom. This method has many advantages. For example, it allows students to understand the semantic content in a comprehensive way in terms of associations with other related words as well as appropriate use in context. It gives them the opportunity to familiarise themselves with a wide scope of vocabulary and also to become independent researchers of the intricacies of studied words. Furthermore, a teacher has the flexibility to choose how long or short the activity should be. In addition it can be very detailed and involve several sessions or it can be used as a warm up at the beginning of a class in a curtailed form. Certainly, this type of activity would be more attractive to students than rote memorisation of a list of vocabulary items.

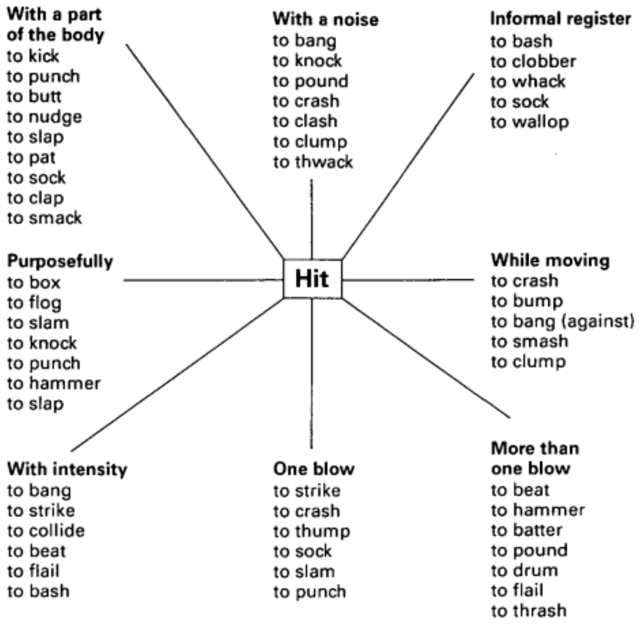

Figure 53. An example of a semantic word map (Jullian, 2000:41)

To conclude this part, learners of L2 need to have an understanding that even those concepts that share translations equivalents across L1 and L2 do not fully share their semantic content and often retain their specific meanings. The use of activities such as the one designed by Jullian (2000) can help students to gain linguistic competence in two languages.

6.4.1.2 Teaching vocabulary that has language/culture specific meaning

Teaching vocabulary that has language/culture specific meaning seems more challenging than teaching words that at least partially share semantic content between two languages. That is, in case of language specific words it is not possible to rely on translation or an association in L1. One can use approximation (e.g. A is like B or A is similar to B), however, it is not a reliable method. When learning L2 vocabulary that does not have counterparts in L1, apart from acquiring the orthography, phonology and morphology, one has to create a new meaning. This process, according to Jiang (2000), might take quite a while since first learners have to understand the new concept before they are able to use it successfully. For instance, Chinese learners might struggle with the English words for *privacy* and *community* as these concepts do not exist in Chinese (ibid, 2000:67). The Chinese word *yǐnsī*（隐私), which is often translated as *privacy,* actually stands for *private matters*; whereas *shèqū*（社区）means *neighbourhood* rather than *community.* Furthermore, Pavlenko (2009) pointed out that words such as *privacy, personal space* or *frustration* do not have conceptual equivalents in Russian. Also, for instance Polish words: *przykro mi*[127] or *obrazić się*[128] do not seem to have equivalent concepts in English. Therefore, in case of *conceptual non-equivalence*, Pavlenko recommended using tasks that facilitate the development of new concepts. For instance, activities such as the presentation of novel objects or awareness-raising discussions are seen by the researcher as very useful. Also, referring back to the above, Jiang (2000) stated that acquisition of *strangers* involves a process of meaning creation. However, once this process is complete *strangers* can be used with greater automaticity and correctness than *real* and *false friends*.

All in all, to teach language/culture specific vocabulary one should use a wide variety of teaching aids. In the case of concrete words, it would be valuable to use realia or pictorial representations of new lexical items. In general, there are not many concrete vocabulary items that can only be found in e.g. English but not Chinese as we all live in a natural environment and we are surrounded by similar natural features and man-made objects. For instance, a dinning table might have a slightly different shape in the U.K. (usually square or rectangular) and China (usually round with a round rotating glass board in the middle) but it still serves the same purpose. In the case of concrete words, it is often the extension of meaning (metaphorical or figurative use) or connotations that differ. Discussion, working with definitions, use in context, and use of concrete

[127] It refers to a state of experiencing/feeling sorry or sad after something unpleasant happened.
[128] It refers to a state/feeling after e.g. an argument, when one person does not want to talk with another person because they feel angry, sad, disappointed.

examples are among just a few methods that can help students learn such specific instances of vocabulary use. For example, to teach students about the different connotations that various colours carry in Chinese and English one could present pictures taken during a traditional Chinese wedding or a Chinese New Year to explain the vast scope of specific connotations that e.g. the colour red carries[129] in Chinese and compare them with photos of fire or an English fire engine. The above mentioned activities can also be helpful in teaching abstract words. For instance, the short movies used by Pavlenko in her research (chapter six, subsection 6.3.1.2), could easily be adapted to teaching tools to visualise the notions of *privacy* and *personal space.*

To sum up this section, instruction focusing on language/culture specific vocabulary has to be rich and detailed in order to facilitate formation of new concepts and assure appropriate usage in context. Several of the suggestions made above can be beneficial in this process.

6.4.1.3 Strengthening the interlexical link between L2 and concepts

It has been demonstrated in this study as well as in, e.g. Jiang (1999) and Kroll and Stewart (1994), that the link between L2 and concepts is weaker than the one connecting L1 and concepts as exemplified by the RHM. This means that often especially during early stages of L2 learning students rely on mediation through L1 to access the meaning of L2 words. Access from L2 to concepts is more direct and faster, therefore strategies for strengthening the interlexical link between L2 and concepts should be considered. The most obvious way to do this is to eliminate the use of L1 from the teaching context. This notion was already suggested over a century ago by Epstein (1915 in Pavlenko 2011:12) who promoted the use of the Direct Method. According to Epstein this method

[129] Red in Chinese culture means good luck, good fortune, prosperity, happiness and joy. Brides wear traditional red dresses during the wedding. Children receive red pockets (envelopes) with money and people wear red clothes during the Chinese New Year.

of teaching "assists the formation of direct links between 'thought' and L2 words [and] eliminates translation exercises and the mother tongue of the pupils from the classroom". As indicated by Pavlenko (2011), it was later adopted by the immersion approaches. Nevertheless, Jiang (2004) argued that even though intralingual strategies [130] are preferred among teachers and are seen as "pedagogically correct[131]" (Schmitt, 1997 in Jiang, 2004), they are not beneficial for the students, for use of only L2 often involves inferring new meanings from context.

As pointed out by Jiang (2004), there is a lot of research demonstrating that guessing is frequently unsuccessful and it may lead to lexical errors. On the other hand, use of L1 translation is quick and efficient. It gives students confidence in learning new meanings; it also helps them to make associations with already existing (in most cases) concepts in L1 and therefore new words are easier to retain regarding their semantic content in the long term memory. Furthermore, Jiang (2004:426) contended that L1 involvement in L2 learning cannot be avoided as often L2 words are mapped to the semantic content of L1 semantic structures (at least in adult learners) and therefore "there is no reason not to use L1 as a means of semantization or as a tool for checking and validating learners' understanding of word meaning".

In conclusion, the use of L1 translation should not be seen as having a detrimental effect on students' lexical competence. The use of intralingual strategies to strengthen the interlexical connections between L2 and concepts can be successful but only at more advanced stages of learning. Once students have acquired sufficient knowledge of L2, they can rely on monolingual dictionaries, use of synonyms and use of L2 context to gain

[130] Jiang (2004) made a distinction between intralingual (use of only L2 instruction), interlingual (use of both L1 and L2 instruction), and extralingual (pictures, object, multimedia) strategies.
[131] Schmitt (1997 in Jiang 2004) explained that many teachers see intralingual strategies as being in line with the communicative approach to teaching.

new semantic content. Moreover, retaining a strong link between L1 and L2 is also important as proficient translation between two languages is a valuable skill to have.

All in all, in this chapter the ecological validity of psycholinguistic data has been discussed and some useful suggestions on increasing the validity made. Furthermore, the implications of psycholinguistic findings to the SLL have been addressed and in particular, application of the RHM, with its slight modification to the conceptual store, to the education context has been discussed. The next chapter will address the areas of enquiry that have not been extensively researched and which are worthwhile for further examination.

CHAPTER SEVEN

FUTURE RESEARCH

In this chapter the direction of future psycholinguistic investigations is discussed. The major focus of this discourse is on the impact of psycholinguistic studies, increasing ecological validity, and strengthening collaboration between psycholinguists and neurolinguists. Furthermore, several research areas of future interest are considered. In particular, developing a framework that will act as a global predictor of *conceptual reconstructuring* (Pavlenko, 2011), finding the locus of the priming asymmetry effect, and investigating multilingual language processing are discussed.

7.1 Direction of future research

There are many aspects in the field of psycholinguistics that have received little research attention. For instance, Pavlenko (2011) mentioned that *inner speech*[132] has been under researched. Also, scarce investigation has been devoted to multilingual language processing or to external factors, such as tiredness or self-confidence, which might influence language control and all these elements are certainly worth further examination. However, psycholinguistics as a field of study/research has to direct attention to more comprehensive notions, i.e. the notion of impact, which is closely related to the notion of ecological validity, and also there needs to be closer collaboration between psycholinguistics and neurolinguists. This specific research direction, which in this researcher's point of view should be adopted by psycholinguistic investigations, has been advocated by Libben and Jarema (2002) in the organizational framework for research in the mental lexicon (presented in chapter six, section 6.2). The framework is very

[132] Pavlenko (2011:242) defined *inner speech* as "subvocal or silent self-talk, i.e. mental activity that takes place in an identifiable linguistic code and is directed primarily at self".

powerful and the message that it sends can be achieved by standardising research methods, developing new methods to address multilingual language processing, and relying on joint collaboration during psycholinguistic and neurolinguistic investigations.

It is important to standardise the paradigms used in psycholinguistic research, for instance the masked priming task. Regarding this, it has been shown before that varied task demands produce different results (e.g. Durgunolu and Roediger, 1987; Li et al., 2009; Zeelenberg and Pecher, 2003). Furthermore, Grosjean (1998) pointed to the conflicting situation in the field of bilingualism or as Pavlenko (2011:3) puts it "the messiness of bilingualism", which might result from the use of different terminology, different methodology, different analysis and study of different participants. In addition, as skilfully captured by Aitchison (2003:75), "words are [not] stitched together in one's mind like pieces on a patchwork quilt. The shape and the size of the patches would differ from language to language, but within each language any particular patch would be defined with reference to those around it. But this simple idea will not work. Words do not cover the world smoothly, like a jigsaw with interlocking pieces. The whole situation is more like a badly spread bread and butter, with the butter heaped up double in some places while leaving bare patches in others". Therefore, while investigating the representation and processing of those 'badly spread' words in lexical memory, studies should carefully report the number and type of stimuli used as well as the number and type of bilingual participants recruited. This should be done to ensure that particular results are observed under a given set of conditions and that true effects are captured. Moreover, the tasks should become more specialised. That is, researchers need to differentiate between the levels of word processing, e.g. phonological, orthographic, semantic, syntactic, or morphological and design tasks that tap into a given level of representation. It is true that often it is impossible to fully separate the processes, e.g. as in the case of phonology and orthography (e.g. Perfetti et al., 2005; Perfetti and Tan, 1998, 1999; Perfetti and Zhang, 1991, 1995). However, when a study aims to investigate the semantic level of representation one should not rely on an LDT and instead, an implicit, conceptually driven task should be selected, e.g. a primed animacy or a man-made decision task (Zeelenberg and Pecher, 2003). Finally, studies need to be conducted with varied languages and scripts, for owing to the fact that a great majority of the investigations have focused on the English language, it is difficult to generalise findings to other languages. More focus should be paid to languages of Asia e.g. Chinese, Japanese, Korean, and Hindi, because the different scripts that these languages use might impose certain language processing demands that are not found in e.g. Latin alphabetic languages.

Furthermore, it has to be acknowledged that the research tools that we have available in psycholinguistics nowadays are fairly limiting. Reaction time based tasks are insightful but they cannot give us a depth of understanding, e.g. into the content of the semantic representations (e.g. Pavlenko, 2009). Therefore, it is crucial to develop new tasks, adapt them from other fields of study [133], and/or draw on findings generated by more sophisticated methods of brain imaging from neurolinguistics. The importance of the last point is well exemplified by a study conducted by Thierry and Wu (2007), who used both a behavioural measures and brain potentials to investigate unconscious translation in Chinese-English speakers. As reported by the researchers, the effect (unconscious translation) failed to be elicited in the participants' behavioural performance, but it was clearly visible on EEGs. It was demonstrated that the two languages are activated in parallel and that the participants implicitly accessed the first language even if they were asked to do a task exclusively in the second language (in a monolingual mode). Grosjean

[133] Several cross cultural methods, e.g. a sorting and naming task and a narrative elicitation task have been discussed in chapter 6, subsection 6.3.1.2.

and associates (2003) also encouraged combining findings and collaboration between psycholinguists and neurolinguists. These researchers see this form of collaboration as making headway in better understanding of bilingual language processing and representation (ibid).

To sum up this part, future psycholinguistic research needs to pay more attention to ecological validity, applicability of laboratory findings to real world settings and on gaining more insights from neurolinguistic investigations. This can be achieved by following more constrained experimental designs and strengthening a two-way collaboration between psycholinguists and neurolinguists.

7.2 Areas of future interest

One area of future research that might generate a lot of interesting findings revolves around the notion of *conceptual restructuring*[134] as proposed by Pavlenko (2011). This researcher listed six predictors of conceptual restructuring: (1) the age of L2 acquisition (AOA), (2) the context of acquisition, (3) length of exposure (LOE), (4) language proficiency, (5) frequency of language use and (6) the type of required adjustment (e.g. incorporation of new contrast or suppression of an already existing one) (ibid, 2011: 248-251). Moreover, she stressed that these identified elements all play an important role in the process of second language learning and/or language attrition. Therefore, it would be interesting to develop a framework, which incorporates all the above mentioned elements and thus act as a global predictor of success in the process of L2 learning. Although it would be a challenging task taking into account individual differences between learners,

[134] Pavlenko (2009:150) considered *conceptual restructuring* alongside the development of target-like linguistic categories to be the main goal of L2 learning. She defined *conceptual restructuring* as "changes in speakers' linguistic categories, seen as a subset of cognitive categories" (Pavlenko, 2011:246).

the idea of having a framework with six simple components that can be adjusted so as to ensure language proficiency/competence is very attractive.

Furthermore, it would be of interest to address Jiang's (2004) question regarding the locus of the priming asymmetry effect. As pointed out by this author, priming asymmetry might take place through the direct translation association route between L1 and L2 or it might be conceptually mediated. The examination of this notion would involve designing several tasks, e.g. a priming task. Moreover, one of the paradigms would need to focus on shallow processing (orthographic or phonological) and another on deep processing (semantic). The tasks would also need to be run in two language directions, i.e. from L1 to L2 and vice versa. The comparison of findings obtained from the tasks should shed some light on the location of the priming asymmetry effect.

Also, the proposition regarding the distributed nature of the conceptual level according to the RHM (chapter two, subsection 2.2.1.3) will need to be further investigated. A task, which would incorporate common semantic elements as well as language/culture specific concepts, would need to be designed and a cross language priming task would be well suited for this. This is because it would allow for varying the relationship between primes and targets in two languages, in that one could manipulate the relatedness between primes and targets and observe whether a priming effect occurs only from the common elements or also from language/culture specific ones.

Finally, multilingual language processing is an area of research that has been greatly overlooked and which deserves to be more thoroughly examined since more and more people around the world are proficient in more than two languages. It would be intriguing to investigate how three or four languages are stored in memory and how they interact with each other, whether they are activated in parallel or whether e.g. the level of activation depends on the level of proficiency. Based on self observation and on reports from other multilingual friends, it seems that the more proficient languages compete for activation with one another and that the less proficient languages compete with one another, however, it would appear that there is no interference between the languages of differing proficiency. This might be due to different memory structures that are involved in processing, but as yet, this has not been verified in an empirical way.

The field of psycholinguistics is dynamically developing. With each newly conducted study we gain more insight into the way languages are stored in long term memory and into the way in which we gain access to the information stored at different levels of representation. However, to be able to provide a more comprehensive and realistic picture of the bilingual mental lexicon we need to follow constrained experimental examinations and reach out to other disciplines of science, in particular, neurolinguistics. The future of psycholinguistic investigations looks promising and it might be likely that one day the mystery of thinking will be resolved through the study of language.

CHAPTER EIGHT

CONCLUSIONS

This thesis has addressed the representation and processing of the bilingual Chinese-English mental lexicon. In particular, the conceptual level of representation was examined. The aim of this investigation was fourfold. First and second, there was the goal of clarifying the way in which concepts are represented and processed in Chinese-English bilingual memory. Third, there was the intention to extend the scope of the findings by focusing on two modalities: auditory and visual. Finally, the degree of the semantic overlap between the two languages was to be probed. To meet the aims of this project a group of bilingual Chinese-English participants and two groups of monolingual English and Chinese participants were recruited to take part in several experiments. Four implicit priming tasks in a form of an animacy decision and a semantic judgment task in English and Chinese were used to examine four formulated hypotheses. These addressed the notions of priming effect, priming asymmetry effect, impact of modality, and semantic overlap. The evaluation of each in turn helped to test the Revised Hierarchical Model (Kroll and Stewart, 1994).

A robust priming effect was shown. That is, target items that were preceded by translation equivalents were recognized quicker than those that were preceded by unrelated words. This finding indicates that the conceptual level of representation is shared for Chinese-English speakers. Furthermore, the priming effect was observable in the L1 to L2 language group, but failed to be shown in the opposite language order, i.e. from L2 to L1. This was interpreted as the priming asymmetry effect, which most likely stems from differing strength of the interlexical connections, regarding which it was demonstrated that the connection between L1 and concepts is stronger than the one between L2 and concepts. This finding is in line with the representational account captured by the RHM (Kroll and Stewart, 1994). Furthermore, it was shown that the information in the visual and auditory modalities does not become available at the same time and that the processes are not identical. Targets in the visual modality were recognized more rapidly than words in the auditory; however the reported priming effect was greater in the latter. This finding was explained in terms of differing rates of availability of information over time. Finally, the investigation of the bilingual semantic structures indicated that they differ from the monolingual English and Chinese maps. This was interpreted as evidence for the uniqueness of bilingual speakers (Grosjean, 1989) and a possible process of *semantic convergence* (Ameel et al., 2005, 2009; Pavlenko, 1999).

The evaluation of the hypotheses helped to test the architecture of the RHM (Kroll and Stewart, 1994) as the findings obtained were sufficient to substantiate the theoretical prediction of the model. Nevertheless, based on additional evidence from other studies (e.g. from Dong et al., 2005; Francis, 2005; or Pavlenko, 2009), a modification to the conceptual level of representation was proposed, whereby it was suggested that the conceptual level is distributed. That is, the evidence revealed that there could be two greatly overlapping stores that share common items but also retain language/culture specific concepts. This instantiation however is only hypothetical and still needs to be empirically verified, but would appear reasonable as it has also been accounted for in other lexical memory models e.g. the Shared (distributed) Asymmetrical Model (Dong et al., 2005) or the Modified Hierarchical Model (Pavlenko, 2009).

Furthermore, it was proposed in this thesis that future psycholinguistic investigations should take as guidelines the organizational framework for research in the mental lexicon

(Libben and Jarema, 2002). This framework captures neatly the importance of reporting in great detail the information about a particular set of languages, population studied and tasks used. This should help to understand the results obtained under a particular set of circumstances, and how to compare findings from the various investigations. Furthermore, the framework emphasises the importance of combining psycholinguistic and neurolinguistic findings, and discussing them in terms of the role they play in real world communication. Moreover, ecological validity is seen by this researcher as a crucial element for all psycholinguistic investigations. Hence, several ways of increasing the validity of language processing findings have been put forth and the applicability of the RHM (Kroll and Stewart, 1994) to second language learning instruction discussed. Several teaching suggestions were offered based on the representation of the conceptual store. For example, it was proposed that teaching vocabulary that shares or partially shares concepts between L1 and L2, should focus on stressing similarities and differences between words. Moreover, strategies that rely on explicit instruction, contrastive analysis (Jiang, 2004), translation from L1 to L2, recall of L2 words, and metaphorical extensions of L2 words (Pavlenko, 2009) should be engaged with. In the case of concepts that are language/culture specific it was suggested that a variety of tasks that aid the processes of meaning creation should be used (Jiang, 2000) and visual aids, realia, and multimedia were promoted as being particularly useful for this type of instruction. Finally, it was advocated that L1 should not be eliminated fully from second language learning, because although the use of L2 only can be beneficial for strengthening the connections between L2 and concepts, it should be used with students who have already attained a certain level of proficiency in L2. In particular, the use of L1 translation is seen as a useful tool for semantization, checking and validating student understanding of the semantic content (Jiang, 2004).

All in all, this thesis has provided a comprehensive view of the bilingual Chinese-English mental lexicon. It has delivered evidence that at the conceptual level this is shared. Furthermore, the importance of using *conceptually-driven tasks* (Durgunolu and Roediger, 1987) that are *implicit* in nature (Zeelenberg and Pecher, 2003) to address the conceptual level of representation has been uncovered. Moreover, it has contributed to the research literature on the use of an auditory cross-language priming paradigm. Since the importance of Mandarin Chinese is growing steadily worldwide and as the number of Chinese-English bilinguals is increasing, the findings presented in this work are of wider relevance. Future research needs to extend the theoretical preposition of the RHM (Kroll and Stewart, 1994) with particular focus on multilingual language processing.

APPENDIXES

Appendix 1 A – Bilingual information sheet and consent form

Information sheet

The processing and representation of the bilingual Chinese-English mental lexicon

REC Ref: **REP(EM)/10/11-61**

Instructions: Please take your time to read through this information sheet. You will be given a copy of it for your own reference.

We would like to invite you to participate in this postgraduate research project. You should only participate if you want to; choosing not to take part will not disadvantage you in any way. Before you decide whether you want to take part, it is important for you to understand why the research is being done and what your participation will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information.

This project investigates the way in which word meanings are organized and accessed in the bilingual Chinese-English mental lexicon (we can liken the mental lexicon to a dictionary or a database of all words in the mind of the language user). It aims to establish whether Chinese-English bilinguals have one common conceptual store, and if so, display a degree of overlap and access route preference.

We are looking to recruit right-handed male and female participants, age 18 to 25, who are fluent speakers of Mandarin-Chinese and English. (The participants have to be right-handed due to the reaction time based design of the priming task.)

We will invite you to fill in a questionnaire and take part in the priming experiment (a task during which you will need to make an animacy decision about words displayed on the computer screen). Some participants might also be asked to take part in a semantic judgment task during which they will rate similarity of presented words. The whole procedure should take about 15 to 20 minutes and you will be offered a small treat (a box of chocolates) for your time

If you decide to take part, you are still free to withdraw at any time and to withdraw your data up until the end of December 2011 when we will start the data analysis.
The filled in questionnaires will be given random ID numbers that will be matched with the data collected in the two other tasks. Any and all information we collect from the questionnaire and the tasks will be confidential and anonymised. The only people who will know about your participation are: the researcher and her supervisor.

At the end of this project we will publish a report. If you would like to receive a copy, please provide your email address on the contact details sheet. Please note that it will not be possible to identify you from any publications since all the information you provide is confidential and anonymised. Data will be kept and stored securely on KCL premises for five years, after which it will be destroyed.

For more information and advice on this project, please use the details provided below to contact: Ms. Agnieszka Tytus.

Researcher: Ms. Agnieszka Tytus
Department of Education and Professional Studies
King's College London
Franklin-Wilkins Building, Waterloo Bridge Wing
Waterloo Road
London SE1 9NH
Email: agnieszka.tytus@kcl.ac.uk

Supervisor: Dr. Gabriella Rundblad
Department of Education and Professional Studies
King's College London
Franklin-Wilkins Building, Waterloo Bridge Wing
Waterloo Road
London SE1 9NH
Email: gabriella.rundblad@kcl.ac.uk

If this study has harmed you in any way, you can contact King's College London using the details above for further advice and information.

Consent form

KING'S College LONDON

The processing and representation of the bilingual Chinese-English mental lexicon

REC Ref: **REP(EM)/10/11-61**

Instructions: Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

Thank you for considering taking part in this research. The person organising the research must explain the project to you before you agree to take part. If you have any questions arising from the Information Sheet or explanation already given to you, please ask the researcher before you decide whether to join in. You will be given a copy of this Consent Form to keep and refer to at any time.
Please tick to confirm:

- I understand that the information I have submitted will be published as a report and that I can request a copy from the researcher by providing the email contact details. Please note that ☐

confidentiality and anonymity will be maintained and it will not be possible to identify you from any publications.

- I understand that if I decide at any time during the research that I no longer wish to participate in this project, I can notify the researchers involved and withdraw from it immediately without giving any reason. Furthermore, I understand that I will be able to withdraw my data up to December 2011. ☐

- I consent to the processing of my personal information for the purposes explained to me. I understand that such information will be handled in accordance with the terms of the Data Protection Act 1998. ☐

Participant's Statement:
I ____
agree that the research project named above has been explained to me to my satisfaction and I agree to take part in the study. I have read both the notes written above and the Information Sheet about the project, and understand what the research study involves.

Signed ________________________________ Date ________________________

Investigator's Statement:
I ____
confirm that I have carefully explained the nature, demands and any foreseeable risks (where applicable) of the proposed research to the participant.

Signed ________________________________ Date ________________________

Appendix 1 B – English monolingual information sheet and consent form

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Information sheet

The processing and representation of the bilingual Chinese-English mental lexicon

REC Ref: **REP(EM)/10/11-61**

KING'S College LONDON

Instructions: Please take your time to read through this information sheet. You will be given a copy of it for your own reference.

We would like to invite you to participate in this postgraduate research project. You should only participate if you want to; choosing not to take part will not disadvantage you in any way. Before you decide whether you want to take part, it is important for you to understand why the research is being done and what your participation will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information.

This project investigates the way in which word meanings are organized and accessed in the bilingual Chinese-English mental lexicon (we can liken the mental lexicon to a dictionary or a database of all words in the mind of the language user). The project aims to establish how Chinese-English bilinguals store words in memory and how they gain access to them.

We are looking to recruit male and female participants, age 18 to 25, who are monolingual native speakers of English.

We will invite you to fill in a short questionnaire and take part in a semantic judgment task during which you will rate how similar or dissimilar are presented pairs of words. The whole procedure should take about 8 to 10 minutes and you will be offered a small treat (a box of chocolates) for your time.

If you decide to take part, you are still free to withdraw at any time and to withdraw your data up until the end of December 2011 when we will start the data analysis.

Once you have decided to participate, you will be given a random id number, which you will use throughout the data collection stage. All information we collect during the study will be confidential and anonymised. The only people who will know about your participation are: the researcher and her supervisors.

At the end of this project we will publish a report. If you would like to receive a copy, please provide your email address on the contact information sheet. Please note that it will not be possible to identify you from any publications since all information you provide is confidential and anonymised. Data will be kept and stored securely on KCL premises for five years, after which it will be destroyed.

For more information and advice on this project, please use the details provided below to contact: Ms. Agnieszka Tytus.

Researcher: Ms. Agnieszka Tytus
Department of Education and Professional Studies
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Franklin-Wilkins Building, Waterloo Bridge Wing
Waterloo Road
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Email: agnieszka.tytus@kcl.ac.uk

Supervisor: Dr. Gabriella Rundblad
Department of Education and Professional Studies
King's College London
Franklin-Wilkins Building, Waterloo Bridge Wing
Waterloo Road
London SE1 9NH
Email: gabriella.rundblad@kcl.ac.uk

If this study has harmed you in any way, you can contact King's College London using the details above for further advice and information.

Consent form

The processing and representation of the bilingual Chinese-English mental lexicon

REC Ref: **REP(EM)/10/11-61**

Instructions: Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

Thank you for considering taking part in this research. The person organising the research must explain the project to you before you agree to take part. If you have any questions arising from the Information Sheet or explanation already given to you, please ask the researcher before you decide whether to join in. You will be given a copy of this Consent Form to keep and refer to at any time.

Please tick to confirm:

- I understand that the information I have submitted will be published as a report and that I can request a copy from the researcher by providing the email contact details. Please note that confidentiality and anonymity will be maintained and it will not be possible to identify you from any publications. ☐

- I understand that if I decide at any time during the research that I no longer wish to participate in this project, I can notify the researchers involved and withdraw from it immediately without giving any reason. Furthermore, I understand that I will be able to withdraw my data up to December 2011. ☐

- I consent to the processing of my personal information for the purposes explained to me. I understand that such information will be handled in accordance with the terms of the Data Protection Act 1998. ☐

Participant's Statement:

I ____

agree that the research project named above has been explained to me to my satisfaction and I agree to take part in the study. I have read both the notes written above and the Information Sheet about the project, and understand what the research study involves.

Signed ________________________________ Date _______________________

Investigator's Statement:

I ____

confirm that I have carefully explained the nature, demands and any foreseeable risks (where applicable) of the proposed research to the participant.

Signed ________________________________ Date _______________________

Appendix 1 C – Chinese monolingual information sheet and consent form

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信息函件

汉英双语者心里词汇的处理和存取

The processing and representation of the bilingual Chinese-English mental lexicon

REC Ref: **REP(EM)/10/11-61**

<u>说明</u>：请详细阅读下面文字。

我们非常高兴邀请您参加一项研究生课题。是否选择参加本项目秉着自愿的原则，您不参加也不会给您带来任何负面影响。在您作出决定之前，您有必要了解关于此项研究的具体信息。如果您有疑问或需要更详细的信息，请与我们取得联系。

本研究探讨词汇是如何在汉英双语者心里词汇中处理和存取的（我们可以将心里词汇比喻成语言使用者大脑中的字典或者数据库）。

本研究以年龄在 18-25 岁之间，以汉语（普通话）为母语且不会其他外语的男性或女性为研究对象。

我们将邀请您完成一份调查问卷，并参加一项简短的测试（判断两个词汇的相似程度）。整个过程需要大约 8-10 分钟。为了感谢您对本项目的支持，您在完成问卷调查和测试后将获得一盒巧克力。

如果您选择参加本项研究，您有权在 2011 年 12 月（研究人员开始分析数据）之前的任何时间选择退出。

在您决定参加本项研究之后，我们将给您一个 ID 号码用于数据收集。所收集的全部数据都将得到保密。唯一知道您信息的人只有研究者及其导师。

本项研究结束时，我们将发表一份报告。如果您愿意阅读研究结果，我们可以通过 email 将报告发给您。请在联络信息中注明您的 email 信息。最后出版的报告不会涉及您个人的信息，因为您所提供的信息都是保密的，匿名的。数据将被安全的储存于伦敦国王学院，5 年之后我们将销毁全部数据。

<u>请与我们取得联系以获得关于此项研究的详细信息</u>

<u>研究者:</u> Ms. Agnieszka Tytus
Department of Education and Professional Studies

King’s College London
Franklin-Wilkins Building, Waterloo Bridge Wing
Waterloo Road
London SE1 9NH
Email: agnieszka.tytus@kcl.ac.uk

导师: Dr. Gabriella Rundblad
Department of Education and Professional Studies
King’s College London
Franklin-Wilkins Building, Waterloo Bridge Wing
Waterloo Road
London SE1 9NH
Email: gabriella.rundblad@kcl.ac.uk

如果这项研究以任何方式伤害到你，你可以使用上述材料联系伦敦国王学院以获取详细意见和信息。

项目人员同意书

The processing and representation of the bilingual Chinese-English mental lexicon
汉英双语者心里词汇的处理和 存 取
REC Ref: **REP(EM)/10/11-61**

注意事项：请在阅读关于本研究项目的说明之后填写下面表格

非常感谢您对此研究项目的兴趣。组织研究的人员必须在您同意参加此项目之前向您解释说明本研究的相关内容。如果您对所阅读的研究项目说明书有任何疑问，请在同意参加此项目前向研究人员咨询。我们将给您一份同意书的副本供您保存和随时参考。

请打勾确认

- 我了解所提供的信息将会用于出版一份研究报告，并且了解可以通过提供本人 email 信息向研究人员索取研究报告。您的信息将得到严格的保密，研究报告不会公布您的个人信息。 ☐
- 我了解可以在研究中的任何时候退出并且不需要向研究人员做出任何解释。此外，我了解 2011 年 12 月之前都可以撤出我所提供的数据信息。 ☐
- 本人同意将个人信息用于已经向我解释的研究项目。我了解此类信息的处理将遵循 1998 年信息保护法中的相关条款。 ☐

项目参与人员声明

我 ____

同意参加此项研究。我已阅读上述说明以及研究说明书中的内容，并且了解此研究所涉及的内容。

签名 日期

______________________________ ______________________

____

研究人员声明:

我 ____

确认已经仔细向研究参与者解释了本研究的本质、需求及可预见性的风险。

签名 日期

______________________________ ______________________

Appendix 2 – Template of the bilingual questionnaire

Biographic questionnaire

INSTRUCTIONS: Please answer all the questions by clicking on the box next to the answer that applies to you most or by providing a written answer. Please write your answers in English. You are allowed to tick only one box per question unless otherwise indicated.

Please enter your ID number_________________

Part 1 – Personal details

Q1. How old are you?

☐ 17 or under ☐ 26 – 29
☐ 18 – 21 ☐ 30 – 33
☐ 22 – 25 ☐ 34 or above

Q2. Are you male or female?

☐ male ☐ female

Q3. What is the level of your programme of study?

☐ undergraduate
☐ postgraduate
☐ other – please specify_______________________

Q4. Which country were you born in?

____

Q5. How long have you lived in Hong Kong / the UK for?

☐ less than 1 year
☐ 1 - 2 years
☐ 3 - 4 years
☐ 5 - 6 years
☐ more than 6 years

Q6. Which language was your primary education in?

☐ Chinese ☐ English

Q7. Which language was your secondary education in?

☐ Chinese ☐ English

Q8. How old were you when you began learning English?

____

Q9. Where did you learn English? Tick all that apply.
☐ school
☐ home
☐ both
☐ other - please specify ________________________

Q10. Were you brought up in two languages at the same time?
☐ yes ☐ no

Q11. In what kind of context do you use Chinese? Tick all that apply.
☐ school ☐ parents
☐ brothers/sisters ☐ grandparents
☐ friends ☐ church
☐ other - please specify ________________________

Q12. In what kind of context do you use English? Tick all that apply.
☐ school ☐ parents
☐ brothers/sisters ☐ grandparents
☐ friends ☐ church
☐ other - please specify ________________________

Q13. Would you describe yourself as bilingual?
☐ yes ☐ no

Q14. Are you equally proficient in both Chinese and English?
☐ yes ☐ no

Q15. Is one of your languages more dominant (more proficient)?
☐ yes ☐ no

Q15a. If yes, which one?

____

Q16. Do you speak any other languages, apart from Chinese and English?
☐ yes ☐ no

Q16a. If yes, which ones?

____

Q17. Are you right-handed or left-handed?
☐ right-handed ☐ left-handed ☐ both

Language ability scale
Q18. How well do you understand spoken English?
☐ not well at all ☐ not so well ☐ pretty well ☐ very well

Q19. How well do you understand written English?
☐ not well at all ☐ not so well ☐ pretty well ☐ very well

Q20. How well do you speak in English?
☐ not well at all ☐ not so well ☐ pretty well ☐ very well

Q21. How well do you write in English?
☐ not well at all ☐ not so well ☐ pretty well ☐ very well

Q22. How well do you read in English?
☐ not well at all ☐ not so well ☐ pretty well ☐ very well

Q23. How good is your use of grammar in English?
☐ not good at all ☐ not so good ☐ pretty good ☐ very good

Part 3 – Language preference

Q24. Which of your languages do you prefer to use in general?

☐ Chinese ☐ English

Q25. Which language do you use most of the time?

☐ Chinese ☐ English

Q26. Which language do you most often think in?

☐ Chinese ☐ English

Q27. In which language do you most often carry out easy mathematical calculations, e.g. 2+2=?

☐ Chinese ☐ English

Q28. In which language do you most often watch television?

☐ Chinese ☐ English

Q29. In which language do you most often read books?

☐ Chinese ☐ English

Q30. In which language do you understand humour better?

☐ Chinese ☐ English

Thank you for taking your time to fill in this questionnaire.

Appendix 3 A – Template of the English monolingual questionnaire

---

Biographic questionnaire

INSTRUCTIONS: Please answer all the questions by clicking on the box next to the answer that applies to you most or by providing a written answer. You are allowed to tick only one box per question unless otherwise indicated.

Please enter your ID number_________________

Personal details

Q1. How old are you?

☐ 17 or under
☐ 18 – 21
☐ 22 – 25
☐ 26 – 29
☐ 30 – 33
☐ 34 or above

Q2. Are you male or female?

☐ male ☐ female

Q3. What is the level of your programme of study?

☐ undergraduate
☐ postgraduate
☐ other – please specify________________________

Q4. Which country were you born in?
____

Q5. Which language was your primary education in?
____

Q6. Which language was your secondary education in?
____

Q7. How long have you lived in the UK for?

☐ less than 1 year
☐ 1 - 2 years
☐ 3 - 4 years
☐ 5 – 6 years
☐ more than 6 years

Q8. Do you speak any other languages?

☐ yes ☐ no

Q8a. If yes, which ones?

____

Q8b. If you speak any other language than English what is the level of your proficiency in that language?

☐ fluent
☐ very good
☐ good
☐ avarage
☐ basic

Q8c. If you speak any other language than English how often do you use it?

☐ most of the time
☐ frequently
☐ often
☐ sometimes
☐ rarely

Q8d. In what kind of context do you use the other language?

☐ school
☐ parents
☐ brothers/sisters
☐ grandparents
☐ friends
☐ church
other _______________

Thank you for taking your time to fill in this questionnaire.

Appendix 3 B – Template of the Chinese monolingual questionnaire

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Biographic questionnaire

说明：请回答下面全部的问题，并在最合适选项前画√或者填写相关信息。每个问题只能选择一个答案。

ID 号码____________________

个人信息

Q1. 您的年龄是？

☐ < 17 ☐ 26 – 29
☐ 18 – 21 ☐ 30 – 33
☐ 22 – 25 ☐ > 34

Q2. 您的性别是?

☐ 男 ☐ 女

Q3. 您目前学习的项目是什么层次?

☐ 本科
☐ 研究生
☐ 其它 （请提供详细信息）_________________________

Q4. 您出生于哪个国家?

____

Q5. 您小学阶段的学习是用哪种语言？

____

Q6. 您中学阶段的学习是用哪种语言?

____

Q7. 您在中国生活了多久?

☐ 少于 1 年
☐ 1 - 2 年
☐ 3 - 4 年
☐ 5 – 6 年
☐ 超过 6 年

Q8. 您是否会讲其他外语?

☐ 会 ☐ 不会

Q8a. 如果您会其他外语，都是哪些?

____

Q8b. 如果你还讲除英语之外的语言，那你对该语言的熟练程度是？

☐ 流利掌握
☐ 很好掌握
☐ 好
☐ 一般掌握
☐ 基本会话

Q8c. 如果你还讲除汉语之外的语言，那你多久使用该语言？

☐ 绝大部分时间
☐ 很经常
☐ 经常
☐ 偶尔
☐ 很少

Q8d. 你在什么情境下使用其他语言？

☐ 学校
☐ 父母
☐ 兄妹
☐ 祖父母
☐ 朋友
☐ 教会
☐ 其它

非常感谢您参加问卷调查

Appendix 4 A – Template of the English contact details form

Contact details sheet

The processing and representation of the bilingual Chinese-English mental lexicon

REC Ref: **REP(EM)/10/11-61**

Instructions: Please provide your contact details in the chart below. Your name and/or your email address will not be used or referred to at any stage in this project or in any future publications. You are assigned an ID number, which you will use throughout the data collection stage. We may use your email address to forward a copy of the final report, if you would like to receive one.

ID NUMBER	
NAME	
EMAIL ADDRESS	

Would you like to receive a copy of the final report? YES ☐ NO☐

Appendix 4 B – Template of the Chinese contact details form

联络信息

汉英双语者心理词汇的处理和存取

The processing and representation of the bilingual Chinese-English mental lexicon

REC Ref: **REP(EM)/10/11-61**

说明：请在下面的表格中填写您的联系方式。您的姓名和联络信息将不会出现在研究报告及今后的出版物中。我们为您提供的 ID 号码将作为数据收集过程中确定您身份的 唯一信息。如果您愿意，我们会将本研究的最终报告发到您的邮箱。

ID	
姓名	
电子邮箱地址	

您是否愿意接收一份本研究的最终报告? 愿意 ☐ 不愿意 ☐

Appendix 5 – List of critical pairs used in the priming task

related – living		related - nonliving	
English primes / targets	**Chinese primes / targets**	**English primes / targets**	**Chinese primes / targets**
cow	母牛 mǔniú	stone	石头 shítou
teacher	老师 lǎoshī	book	书本 shūběn
panda	熊猫 xióngmāo	plane	飞机 fēijī
actor	演员 yǎnyuán	map	地图 dìtú
doctor	医生 yīshēng	pencil	铅笔 qiānbǐ
driver	司机 sījī	skirt	裙子 qúnzi
cook	厨师 chúshī	coat	外套 wàitào
camel	骆驼 luòtuo	shirt	衬衫 chènshān
donkey	驴子 lǘzi	belt	皮带 pi2dài
fox	狐狸 húli	scarf	围巾 wéijīn
sailor	水手 shuǐshǒu	ring	戒指 jièzhi
snail	蜗牛 wōniú	piano	钢琴 gāngqín
son	儿子 érzi	lamp	台灯 táidēng
turkey	火鸡 huǒjī	castle	城堡 chéngbǎo
wife	妻子 qīzi	brush	发刷 fàshuā
worm	虫子 chóngzi	towel	毛巾 máojīn
baby	婴儿 yīng'ér	doll	娃娃 wáwa
groom	新郎 xīnláng	train	火车 huǒchē
child	孩子 háizi	bench	长椅 chángyǐ
dolphin	海豚 hǎitún	box	盒子 hézi
dentist	牙医 yáyī	button	钮扣 niǔkòu
lion	狮子 shīzi	carpet	地毯 dìtǎn
penguin	企鹅 qǐ'é	gift	礼物 lǐwù
seal	海豹 hǎibào	kettle	水壶 shuǐhú
soldier	士兵 shìbīng	key	钥匙 yàoshi
bride	新娘 xīnniáng	kite	风筝 fēngzhēng
clown	小丑 xiǎochǒu	mirror	镜子 jìngzi
postman	邮差 yóuchāi	plate	碟子 diézi
husband	丈夫 zhàngfu	roof	屋顶 wūdǐng
swan	天鹅 tiān'é	shoe	鞋子 xiézi

unrelated – living – L1-L2		unrelated – nonliving – L1-L2	
Chinese primes (English translations)	**English targets**	**Chinese primes (English translations)**	**English targets**
黄蜂 huángfēng (wasp)	cow	村子 cūnzi (village)	stone
宠物 chǒngwù (pet)	teacher	粉笔 fěnbǐ (chalk)	book

飞蛾 fēi'é (moth)	panda	厨房 chúfáng (kitchen)	plane
小狗 xiǎogǒu (puppy)	actor	枕头 zhěntou (pillow)	map
小猫 xiǎomāo (kitten)	doctor	海滩 hǎitān (beach)	pencil
犀牛 xīniú (rhino)	driver	学校 xuéxiào (school)	skirt
野牛 yěniú (bison)	cook	橡胶 xiàngjiāo (rubber)	coat
海狸 hǎilí (beaver)	camel	梳子 shūzi (comb)	shirt
雏菊 chùjú (daisy)	donkey	头盔 tóukuī (helmet)	belt
玫瑰 méigui (rose)	fox	旅馆 lǚguǎn (hotel)	scarf
竹子 zhúzi (bamboo)	sailor	厨灶 chúzào (cooker)	ring
蚂蚁 mǎyǐ (rose)	snail	尺子 chǐzi (ruler)	piano
王子 wángzǐ (prince)	son	饰带 shìdài (ribbon)	lamp
妇女 fùnǚ (woman)	turkey	裤子 kùzi (pants)	castle
苍蝇 cāngying (fly)	wife	勺子 sháozi (spoon)	brush
小鸡 xiǎojī (chick)	worm	骰子 shǎizi (dice)	towel
公牛 gōngniú (bull)	baby	扫帚 sàozhou (broom)	doll
小猪 xiǎozhū (piglet)	groom	书桌 shūzhuō (desk)	train
母鸡 mǔjī (hen)	child	房子 fángzi (house)	bench
乌龟 wūguī (turtle)	dolphin	地板 dìbǎn (floor)	box
强盗 qiángdào (robber)	dentist	钢笔 gāngbǐ (pen)	button
船长 chuánzhǎng (captain)	lion	卡片 kǎpiàn (card)	carpet
龙虾 lóngxiā (lobster)	penguin	淋浴 línyù (shower)	gift
高手 gāoshǒu (expert)	seal	棍子 gùnzi (stick)	kettle
作家 zuòjiā (writer)	soldier	火箭 huǒjiàn (rocket)	key
律师 lǜshī	bride	手表 shǒubiǎo	kite

(lawyer)		(watch)	
经理 jīnglǐ (manager)	clown	水池 shuǐchí (sink)	mirror
绵羊 miányáng (sheep)	postman	时钟 shízhōng (clock)	plate
山羊 shānyáng (goat)	husband	市场 shìchǎng (market)	roof
羔羊 gāoyáng (lamb)	swan	水桶 shuǐtǒng (bucket)	shoe

unrelated – living – L2-L1		unrelated – living – L2-L1	
English primes	**Chinese targets (English translations)**	**English primes**	**Chinese targets (English translations)**
wasp	母牛 mǔniú (cow)	village	石头 shítou (stone)
pet	老师 lǎoshī (teacher)	chalk	书本 shūběn (book)
moth	熊猫 xióngmāo (panda)	kitchen	飞机 fēijī (plane)
puppy	演员 yǎnyuán (actor)	pillow	地图 dìtú (map)
kitten	医生 yīshēng (doctor)	beach	铅笔 qiānbǐ (pencil)
rhino	司机 sījī (driver)	school	裙子 qúnzi (skirt)
bison	厨师 chúshī (cook)	rubber	外套 wàitào (coat)
beaver	骆驼 luòtuo (camel)	comb	衬衫 chènshān (shirt)
daisy	驴子 lǘzi (donkey)	helmet	皮带 pi2dài (belt)
rose	狐狸 húli (fox)	hotel	围巾 wéijīn (scarf)
bamboo	水手 shuǐshǒu (sailor)	cooker	戒指 jièzhi (ring)
ant	蜗牛 wōniú (snail)	ruler	钢琴 gāngqín (piano)
prince	儿子 érzi (son)	ribbon	台灯 táidēng (lamp)
woman	火鸡 huǒjī (turkey)	pants	城堡 chéngbǎo (castle)
fly	妻子 qīzi (wife)	spoon	发刷 fàshuā (brush)
chick	虫子 chóngzi (worm)	dice	毛巾 máojīn (towel)
bull	婴儿 yīng'ér	broom	娃娃 wáwa

	(baby)		(doll)
piglet	新郎 xīnláng (groom)	desk	火车 huǒchē (train)
hen	孩子 háizi (child)	house	长椅 chángyǐ (bench)
turtle	海豚 hǎitún (dolphin)	floor	盒子 hézi (box)
robber	牙医 yáyī (dentist)	pen	钮扣 niǔkòu (button)
captain	狮子 shīzi (lion)	card	地毯 dìtǎn (carpet)
lobster	企鹅 qǐ'é (penguin)	shower	礼物 lǐwù (gift)
expert	海豹 hǎibào (seal)	stick	水壶 shuǐhú (kettle)
writer	士兵 shìbīng (soldier)	rocket	钥匙 yàoshi (key)
lawyer	新娘 xīnniáng (bride)	watch	风筝 fēngzhēng (kite)
manager	小丑 xiǎochǒu (clown)	sink	镜子 jìngzi (mirror)
sheep	邮差 yóuchāi (postman)	clock	碟子 diézi (plate)
goat	丈夫 zhàngfu (husband)	market	屋顶 wūdǐng (roof)
lamb	天鹅 tiān'é (swan)	bucket	鞋子 xiézi (shoe)

Appendix 6 – Priming stimuli letter and stroke counts

trial stimuli			
Chinese words	number of strokes	English words	number of letter
河马 hémǎ	11	hippo	5
歌手 gēshǒu	18	singer	6
农民 nóngmín	11	monkey	6
鸽子 gēzi	14	nurse	5
仓鼠 cāngshǔ	17	garage	6
鸭子 yāzi	13	swing	5
贝壳 bèiké	11	shell	5
冰箱 bīngxiāng	21	fridge	6
笼子 lóngzi	14	tray	4
蜡烛 làzhú	24	balloon	7
车轮 chēlún	12	zebra	5
肥皂 féizào	15	shark	5
fillers			
青蛙 qīngwā	20	pocket	6
兔子 tùzi	11	shop	4
老虎 lǎohǔ	14	brick	5
画家 huàjiā	19	table	5
法官 fǎguān	16	chair	5
国王 guówáng	12	door	4
女士 nǚshì	6	car	3
姐妹 jiěmèi	16	bottle	6
女孩 nǚhái	12	window	6
朋友 péngyou	12	glove	5
抽屉 chōuti	16	vet	3
电梯 diàntī	16	man	3
滑梯 huáti	23	boy	3
街道 jiēdào	24	mouse	5
胶水 jiāoshuǐ	14	whale	5
绳子 shéngzi	14	mother	6
帽子 màozi	15	father	6
杯子 bēizi	11	brother	7
领带 lǐngdài	20	student	7
袜子 wàzi	14	queen	5
related – living			
母牛 mǔniú	15	cow	3
老师 lǎoshī	12	teacher	7
熊猫 xióngmāo	25	panda	5
演员 yǎnyuán	21	actor	5

医生 yīshēng	13	doctor	6
司机 sījī	11	driver	6
厨师 chúshī	18	cook	4
骆驼 luòtuo	17	camel	5
驴子 lǘzi	10	donkey	6
狐狸 húli	18	fox	3
水手 shuǐshǒu	8	sailor	6
蜗牛 wōniú	17	snail	5
儿子 érzi	5	son	3
火鸡 huǒjī	11	turkey	6
妻子 qīzi	11	wife	4
虫子 chóngzi	21	worm	4
婴儿 yīng'ér	13	baby	4
新郎 xīnláng	21	groom	5
孩子 háizi	12	child	5
海豚 hǎitún	21	dolphin	7
牙医 yáyī	12	dentist	7
狮子 shīzi	12	lion	4
企鹅 qǐ'é	18	penguin	7
海豹 hǎibào	20	seal	4
士兵 shìbīng	10	soldier	7
新娘 xīnniáng	23	bride	5
小丑 xiǎochǒu	7	clown	5
邮差 yóuchāi	16	postman	7
丈夫 zhàngfu	7	husband	7
天鹅 tiān'é	16	swan	4
related – non-living			
石头 shítou	10	stone	5
书本 shūběn	9	book	4
飞机 fēijī	9	plane	5
地图 dìtú	14	map	3
铅笔 qiānbǐ	20	pencil	6
裙子 qúnzi	15	skirt	5
外套 wàitào	15	coat	4
衬衫 chènshān	16	shirt	5
皮带 pi2dài	14	belt	4
围巾 wéijīn	10	scarf	5
戒指 jièzhi	16	ring	4
钢琴 gāngqín	21	piano	5
台灯 táidēng	11	lamp	4
城堡 chéngbǎo	21	castle	6
发刷 fàshuā	13	brush	5
毛巾 máojīn	7	towel	5
娃娃 wáwa	18	doll	4
火车 huǒchē	8	train	5
长椅 chángyǐ	16	bench	5
盒子 hézi	14	box	3

钮扣 niǔkòu	15	button	6
地毯 dìtǎn	18	carpet	6
礼物 lǐwù	13	gift	4
水壶 shuǐhú	14	kettle	6
钥匙 yàoshi	20	key	3
风筝 fēngzhēng	16	kite	4
镜子 jìngzi	19	mirror	6
碟子 diézi	17	plate	5
屋顶 wūdǐng	17	roof	4
鞋子 xiézi	18	shoe	4
unrelated – living			
黄蜂 huángfēng	24	wasp	4
宠物 chǒngwù	16	pet	3
飞蛾 fēi'é	16	moth	4
小狗 xiǎogǒu	11	puppy	5
小猫 xiǎomāo	14	kitten	6
犀牛 xīniú	16	rhino	5
野牛 yěniú	15	bison	5
海狸 hǎilí	20	beaver	6
雏菊 chùjú	24	daisy	5
玫瑰 méigui	21	rose	4
竹子 zhúzi	9	bamboo	6
蚂蚁 mǎyǐ	18	ant	3
王子 wángzǐ	7	prince	6
妇女 fùnǚ	9	woman	5
苍蝇 cāngying	21	fly	3
小鸡 xiǎojī	10	chick	5
公牛 gōngniú	8	bull	4
小猪 xiǎozhū	14	piglet	6
母鸡 mǔjī	13	hen	3
乌龟 wūguī	11	turtle	6
强盗 qiángdào	23	robber	6
船长 chuánzhǎng	15	captain	7
龙虾 lóngxiā	14	lobster	7
高手 gāoshǒu	14	expert	6
作家 zuòjiā	16	writer	6
律师 lǜshī	15	lawyer	6
经理 jīnglǐ	19	manager	7
绵羊 miányáng	17	sheep	5
山羊 shānyáng	10	goat	4
羔羊 gāoyáng	16	lamb	4
unrelated – non-living			
村子 cūnzi	10	village	7
粉笔 fěnbǐ	20	chalk	5
厨房 chúfáng	20	kitchen	7
枕头 zhěntou	13	pillow	6
海滩 hǎitān	23	beach	5

学校 xuéxiào	18	school	6
橡胶 xiàngjiāo	25	rubber	6
梳子 shūzi	14	comb	4
头盔 tóukuī	16	helmet	6
旅馆 lǚguǎn	20	hotel	5
厨灶 chúzào	19	cooker	6
尺子 chǐzi	7	ruler	5
饰带 shìdài	17	ribbon	6
裤子 kùzi	15	pants	5
勺子 sháozi	6	spoon	5
骰子 shǎizi	15	dice	4
扫帚 sàozhou	14	broom	5
书桌 shūzhuō	14	desk	4
房子 fángzi	11	house	5
地板 dìbǎn	14	floor	5
钢笔 gāngbǐ	19	pen	3
卡片 kǎpiàn	9	card	4
淋浴 línyù	21	shower	6
棍子 gùnzi	15	stick	5
火箭 huǒjiàn	19	rocket	6
手表 shǒubiǎo	12	watch	5
水池 shuǐchí	10	sink	4
时钟 shízhōng	16	clock	5
市场 shìchǎng	11	market	6
水桶 shuǐtǒng	15	bucket	6

Appendix 7 – List of fillers used in the priming task

English primes / targets	Chinese primes / target [English translation]
nonliving	**living**
pocket	青蛙 qīngwā [frog]
shop	兔子 tùzi [rabbit]
brick	老虎 lǎohǔ [tiger]
table	画家 huàjiā [painter]
chair	法官 fǎguān [judge]
door	国王 guówáng [king]
car	女士 nǚshì [lady]
bottle	姐妹 jiěmèi [sister]
window	女孩 nǚhái [girl]
glove	朋友 péngyou [friend]
living	**nonliving**
vet	抽屉 chōuti [drawer]
man	电梯 diàntī [lift]
boy	滑梯 huátī [slide]
mouse	街道 jiēdào [street]
whale	胶水 jiāoshuǐ [glue]
mother	绳子 shéngzi [rope]
father	帽子 màozi [hat]
brother	杯子 bēizi [cup]
student	领带 lǐngdài [tie]
queen	袜子 wàzi [sock]

Appendix 8 – List of words used in the practise trial of the priming task

English primes / targets	Chinese primes / targets [English translation]
related - living exemplars followed by translation equivalents	
Hippo	河马 hémǎ [hippo]
Singer	歌手 gēshǒu [singer]
unrelated – living exemplars followed by unrelated translations	
Monkey	农民 nóngmín [farmer]
Nurse	鸽子 gēzi [pigeon]
fillers – non-living exemplars followed by living exemplars	
Garage	仓鼠 cāngshǔ [hamster]
Swing	鸭子 yāzi [duck]
related – non-living exemplars followed by translation equivalents	
Shell	贝壳 bèiké [shell]
Fridge	冰箱 bīngxiāng [fridge]
unrelated – non-living exemplars followed by unrelated translations	
Tray	笼子 lóngzi [cage]
Balloon	蜡烛 làzhú [candle]
fillers – living exemplars followed by non-living exemplars	
Zebra	车轮 chēlún [wheel]
Shark	肥皂 féizào [soap]

Appendix 9 – Length of the auditory stimuli used in the priming task

Chinese words	length of Chinese targets	length of Chinese time compressed primes	English words	length of English targets	length of English time compressed primes
			trial stimuli		
河马 hémǎ	700ms	350ms	hippo	550ms	275ms
歌手 gēshǒu	650ms	325ms	singer	600ms	300ms
农民 nóngmín	800ms	400ms	monkey	600ms	300ms
鸽子 gēzi	650ms	325ms	nurse	600ms	300ms
仓鼠 cāngshǔ	650ms	325ms	garage	550ms	275ms
鸭子 yāzi	650ms	325ms	swing	700ms	350ms
贝壳 bèiké	750ms	375ms	shell	700ms	350ms
冰箱 bīngxiāng	750ms	375ms	fridge	550ms	275ms
笼子 lóngzi	750ms	375ms	tray	600ms	300ms
蜡烛 làzhú	700ms	350ms	balloon	700ms	350ms
车轮 chēlún	750ms	375ms	zebra	600ms	300ms
肥皂 féizào	650ms	325ms	shark	550ms	275ms
			fillers		
青蛙 qīngwā	800ms	400ms	pocket	650ms	325ms
兔子 tùzi	750ms	375ms	shop	600ms	300ms
老虎 lǎohǔ	750ms	375ms	brick	550ms	275ms
画家 huàjiā	750ms	375ms	table	600ms	300ms
法官 fǎguān	750ms	375ms	chair	650ms	325ms
国王 guówáng	750ms	375ms	door	650ms	325ms
女士 nǚshì	800ms	400ms	car	650ms	325ms
姐妹 jiěmèi	800ms	400ms	bottle	600ms	300ms
女孩 nǚhái	800ms	400ms	window	700ms	350ms
朋友 péngyou	700ms	350ms	glove	650ms	325ms
抽屉 chōuti	650ms	325ms	vet	550ms	275ms
电梯 diàntī	750ms	375ms	man	650ms	325ms
滑梯 huáti	750ms	375ms	boy	650ms	325ms
街道 jiēdào	700ms	350ms	mouse	650ms	325ms
胶水 jiāoshuǐ	800ms	400ms	whale	700ms	350ms
绳子 shéngzi	750ms	375ms	mother	700ms	350ms
帽子 màozi	650ms	325ms	father	700ms	350ms
杯子 bēizi	650ms	325ms	brother	700ms	350ms
领带 lǐngdài	750ms	375ms	student	700ms	350ms
袜子 wàzi	650ms	325ms	queen	700ms	350ms
			Related - living		
母牛 mǔniú	800ms	400ms	cow	650ms	325ms
老师 lǎoshī	800ms	400ms	teacher	650ms	325ms
熊猫 xióngmāo	800ms	400ms	panda	700ms	350ms
演员 yǎnyuán	800ms	400ms	actor	700ms	350ms

医生 yīshēng	650ms	325ms	doctor	700ms	350ms
司机 sījī	800ms	400ms	driver	700ms	350ms
厨师 chúshī	800ms	400ms	cook	650ms	325ms
骆驼 luòtuo	800ms	400ms	camel	650ms	325ms
驴子 lǘzi	700ms	350ms	donkey	650ms	325ms
狐狸 húli	700ms	350ms	fox	550ms	275ms
水手 shuǐshǒu	800ms	400ms	sailor	700ms	350ms
蜗牛 wōniú	800ms	400ms	snail	700ms	350ms
儿子 érzi	750ms	375ms	son	550ms	275ms
火鸡 huǒjī	700ms	350ms	turkey	650ms	325ms
妻子 qīzi	750ms	375ms	wife	700ms	350ms
虫子 chóngzi	800ms	400ms	worm	650ms	325ms
婴儿 yīng'ér	800ms	400ms	baby	650ms	325ms
新郎 xīnláng	750ms	375ms	groom	700ms	350ms
孩子 háizi	650ms	325ms	child	650ms	325ms
海豚 hǎitún	750ms	375ms	dolphin	700ms	350ms
牙医 yáyī	750ms	375ms	dentist	800ms	400ms
狮子 shīzi	750ms	375ms	lion	700ms	350ms
企鹅 qǐ'é	800ms	400ms	penguin	700ms	350ms
海豹 hǎibào	750ms	375ms	seal	650ms	325ms
士兵 shìbīng	800ms	400ms	soldier	700ms	350ms
新娘 xīnniáng	800ms	400ms	bride	650ms	325ms
小丑 xiǎochǒu	650ms	325ms	clown	700ms	350ms
邮差 yóuchāi	750ms	375ms	postman	700ms	350ms
丈夫 zhàngfu	700ms	350ms	husband	700ms	350ms
天鹅 tiān'é	750ms	375ms	swan	550ms	275ms
related – non-living					
石头 shítou	800ms	400ms	stone	700ms	350ms
书本 shūběn	800ms	400ms	book	600ms	300ms
飞机 fēijī	750ms	375ms	plane	700ms	350ms
地图 dìtú	800ms	400ms	map	650ms	325ms
铅笔 qiānbǐ	750ms	375ms	pencil	750ms	375ms
裙子 qúnzi	800ms	400ms	skirt	750ms	375ms
外套 wàitào	750ms	375ms	coat	750ms	375ms
衬衫 chènshān	800ms	400ms	shirt	700ms	350ms
皮带 pi2dài	800ms	400ms	belt	700ms	350ms
围巾 wéijīn	800ms	400ms	scarf	800ms	400ms
戒指 jièzhi	650ms	325ms	ring	800ms	400ms
钢琴 gāngqín	700ms	350ms	piano	800ms	400ms
台灯 táidēng	750ms	375ms	lamp	700ms	350ms
城堡 chéngbǎo	800ms	400ms	castle	750ms	375ms
发刷 fàshuā	700ms	350ms	brush	700ms	350ms
毛巾 máojīn	800ms	400ms	towel	800ms	400ms
娃娃 wáwa	750ms	375ms	doll	700ms	350ms
火车 huǒchē	750ms	375ms	train	800ms	400ms
长椅 chángyǐ	750ms	375ms	bench	700ms	350ms
盒子 hézi	650ms	325ms	box	700ms	350ms

钮扣 niǔkòu	700ms	350ms	button	700ms	350ms
地毯 dìtǎn	700ms	350ms	carpet	800ms	400ms
礼物 lǐwù	700ms	350ms	gift	700ms	350ms
水壶 shuǐhú	800ms	400ms	kettle	800ms	400ms
钥匙 yàoshi	650ms	325ms	key	650ms	325ms
风筝 fēngzhēng	650ms	325ms	kite	700ms	350ms
镜子 jìngzi	700ms	350ms	mirror	800ms	400ms
碟子 diézi	650ms	325ms	plate	700ms	350ms
屋顶 wūdǐng	650ms	325ms	roof	750ms	375ms
鞋子 xiézi	750ms	375ms	shoe	600ms	300ms
unrelated – living					
黄蜂 huángfēng	800ms	400ms	wasp	800ms	400ms
宠物 chǒngwù	800ms	400ms	pet	600ms	300ms
飞蛾 fēi'é	800ms	400ms	moth	800ms	400ms
小狗 xiǎogǒu	750ms	375ms	puppy	650ms	325ms
小猫 xiǎomāo	800ms	400ms	kitten	650ms	325ms
犀牛 xīniú	800ms	400ms	rhino	800ms	400ms
野牛 yěniú	800ms	400ms	bison	650ms	325ms
海狸 hǎilí	800ms	400ms	beaver	700ms	350ms
雏菊 chùjú	800ms	400ms	daisy	750ms	375ms
玫瑰 méigui	750ms	375ms	rose	800ms	400ms
竹子 zhúzi	750ms	375ms	bamboo	800ms	400ms
蚂蚁 mǎyǐ	650ms	325ms	ant	650ms	325ms
王子 wángzǐ	700ms	350ms	prince	650ms	325ms
妇女 fùnǚ	800ms	400ms	woman	700ms	350ms
苍蝇 cāngying	700ms	350ms	fly	700ms	350ms
小鸡 xiǎojī	800ms	400ms	chick	550ms	275ms
公牛 gōngniú	800ms	400ms	bull	600ms	300ms
小猪 xiǎozhū	800ms	400ms	piglet	700ms	350ms
母鸡 mǔjī	800ms	400ms	hen	600ms	300ms
乌龟 wūguī	800ms	400ms	turtle	700ms	350ms
强盗 qiángdào	750ms	375ms	robber	700ms	350ms
船长 chuánzhǎng	700ms	350ms	captain	650ms	325ms
龙虾 lóngxiā	800ms	400ms	lobster	800ms	400ms
高手 gāoshǒu	650ms	325ms	expert	750ms	375ms
作家 zuòjiā	700ms	350ms	writer	700ms	350ms
律师 lǜshī	750ms	375ms	lawyer	700ms	350ms
经理 jīnglǐ	700ms	375ms	manager	800ms	400ms
绵羊 miányáng	800ms	400ms	sheep	750ms	375ms
山羊 shānyáng	800ms	400ms	goat	600ms	300ms
羔羊 gāoyáng	650ms	325ms	lamb	600ms	300ms
unrelated – non-living					
村子 cūnzi	800ms	400ms	village	700ms	350ms
粉笔 fěnbǐ	800ms	400ms	chalk	600ms	300ms
厨房 chúfáng	800ms	400ms	kitchen	700ms	350ms
枕头 zhěntou	800ms	400ms	pillow	700ms	350ms
海滩 hǎitān	750ms	375ms	beach	650ms	325ms

学校 xuéxiào	750ms	375ms	school	700ms	350ms
橡胶 xiàngjiāo	800ms	400ms	rubber	650ms	325ms
梳子 shūzi	750ms	375ms	comb	700ms	350ms
头盔 tóukuī	700ms	350ms	helmet	700ms	350ms
旅馆 lǚguǎn	800ms	400ms	hotel	700ms	350ms
厨灶 chúzào	750ms	375ms	cooker	700ms	350ms
尺子 chǐzi	800ms	400ms	ruler	700ms	350ms
饰带 shìdài	750ms	375ms	ribbon	700ms	350ms
裤子 kùzi	650ms	325ms	pants	600ms	300ms
勺子 sháozi	800ms	400ms	spoon	800ms	400ms
骰子 shǎizi	750ms	375ms	dice	700ms	350ms
扫帚 sàozhou	650ms	325ms	broom	700ms	350ms
书桌 shūzhuō	700ms	350ms	desk	700ms	350ms
房子 fángzi	650ms	325ms	house	700ms	350ms
地板 dìbǎn	650ms	325ms	floor	700ms	350ms
钢笔 gāngbǐ	650ms	325ms	pen	700ms	350ms
卡片 kǎpiàn	650ms	325ms	card	700ms	350ms
淋浴 línyù	700ms	350ms	shower	700ms	350ms
棍子 gùnzi	650ms	325ms	stick	600ms	300ms
火箭 huǒjiàn	650ms	325ms	rocket	700ms	350ms
手表 shǒubiǎo	650ms	325ms	watch	700ms	350ms
水池 shuǐchí	800ms	400ms	sink	700ms	350ms
时钟 shízhōng	750ms	375ms	clock	600ms	300ms
市场 shìchǎng	750ms	375ms	market	700ms	350ms
水桶 shuǐtǒng	650ms	325ms	bucket	600ms	300ms

Appendix 10 – Instructions given to the participants during the priming task

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Instructions displayed in English on the computer screen at the very beginning of the priming experiment in a Chinese prime (L1) – English target (L2) condition

You are about to be see/hear some words.
If the word DOES represent a living exemplar press the YES button.
If the word DOES NOT represent a living exemplar press the NO button.
You will start with a trial session. There are 12 examples in this session.
When you are ready press the space bar to start.

Instructions displayed in English on the computer screen after the trial session, before the main experimental session in a Chinese prime (L1) – English target (L2) condition

This is the end of the trial session.
You will now move to the main experiment. There are 80 examples in this session.
When you are ready press the space bar to start.

Instructions displayed in Chinese on the computer screen at the very beginning of the priming experiment in an English prime (L2) – Chinese target (L1) condition

你将会看到或听到几组词汇.

如果该词汇代表有生命的物体请按“YES”键.

如果该词汇不代表有生命的物体请按“NO”键.

你将首先参加试用版的测试. 这里有12组词汇.

如果你准备好了请按空格键开始测试.

Instructions displayed in Chinese on the computer screen after the trial session, before the main experimental session in an English prime (L1) – Chinese target (L2) condition

试用版测试结束.

现在你将开始正式的测试. 这里有80组词汇.

如果你准备好了请按空格键开始测试.

Appendix 11 A – Template of the English semantic judgment task

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Semantic judgment task

INSTRUCTIONS: Rank how similar or dissimilar are the listed pairs of words on a six point scale, with 6 representing very similar in meaning and 1 representing very dissimilar in meaning. You are allowed to tick only one box in each example.

For example, if you see a pair of words: SHARK - WHALE, rank how similar or dissimilar in meaning the words are and provide your answer by clicking on a number from 6 to 1.

Please enter your ID number_________________

1.	word A – word B	**6** ☐	**5** ☐	**4** ☐	**3** ☐	**2** ☐	**1** ☐
2.	word A – word C	**6** ☐	**5** ☐	**4** ☐	**3** ☐	**2** ☐	**1** ☐
3.	word A – word D	**6** ☐	**5** ☐	**4** ☐	**3** ☐	**2** ☐	**1** ☐
	(…)						
64.	word J – word K	**6** ☐	**5** ☐	**4** ☐	**3** ☐	**2** ☐	**1** ☐
65.	word J – word L	**6** ☐	**5** ☐	**4** ☐	**3** ☐	**2** ☐	**1** ☐
66.	word K – word L	**6** ☐	**5** ☐	**4** ☐	**3** ☐	**2** ☐	**1** ☐

Appendix 11 B – Template of the Chinese semantic judgment task

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语义判断测试

请判断两组词汇的相似程度。 请在 1-6 直接做出选择: 1 代表词义最不相似, 6 代表词义最为相似。

例子：如果你看到一组词汇是：鲨鱼 – 鲸鱼，请通过选择数字 1-6 来评价两个词汇意思的相似程度。 6 代表非常相似；1 代表非常不同。

请填写您的 ID 号码。

	6	5	4	3	2	1
1. 一字 A – 一字 B	☐	☐	☐	☐	☐	☐
2. 一字 A – 一字 C	☐	☐	☐	☐	☐	☐
3. 一字 A – 一字 D	☐	☐	☐	☐	☐	☐

(…)

	6	5	4	3	2	1
64. 一字 J – 一字 K	☐	☐	☐	☐	☐	☐
65. 一字 J – 一字 L	☐	☐	☐	☐	☐	☐
66. 一字 K – 一字 L	☐	☐	☐	☐	☐	☐

Appendix 12 – List of the animal names used in the semantic judgment task

animal names used in the semantic judgment task	
Chinese words	**English words**
蚂蚁 mǎyǐ	ant
母牛 mǔniú	cow
大象 dàxiàng	elephant
熊猫 xióngmāo	panda
骆驼 luòtuo	camel
蜘蛛 zhīzhū	spider
蜜蜂 mìfēng	bee
狮子 shīzi	lion
猴子 hóuzi	monkey
蝴蝶 húdié	butterfly
兔子 tùzi	rabbit
老虎 lǎohǔ	tiger

Appendix 13 – List of pairs of animal terms used in the semantic judgment task

pairs of animal terms used in the semantic judgment task		
no.	**Chinese pairs of word**	**English pairs of words**
1.	蚂蚁 mǎyǐ – 母牛 mǔniú	ant – cow
2.	蚂蚁 mǎyǐ – 大象 dàxiàng	ant – elephant
3.	蚂蚁 mǎyǐ – 熊猫 xióngmāo	ant – panda
4.	蚂蚁 mǎyǐ – 骆驼 luòtuo	ant – camel
5.	蚂蚁 mǎyǐ – 蜘蛛 zhīzhū	ant – spider
6.	蚂蚁 mǎyǐ – 蜜蜂 mìfēng	ant – bee
7.	蚂蚁 mǎyǐ – 狮子 shīzi	ant – lion
8.	蚂蚁 mǎyǐ – 猴子 hóuzi	ant – monkey
9.	蚂蚁 mǎyǐ – 蝴蝶 húdié	ant – butterfly
10.	蚂蚁 mǎyǐ – 兔子 tùzi	ant – rabbit
11.	蚂蚁 mǎyǐ – 老虎 lǎohǔ	ant – tiger
12.	母牛 mǔniú – 大象 dàxiàng	cow – elephant
13.	母牛 mǔniú – 熊猫 xióngmāo	cow – panda
14.	母牛 mǔniú – 骆驼 luòtuo	cow – camel
15.	母牛 mǔniú – 蜘蛛 zhīzhū	cow – spider
16.	母牛 mǔniú – 蜜蜂 mìfēng	cow – bee
17.	母牛 mǔniú – 狮子 shīzi	cow – lion
18.	母牛 mǔniú – 猴子 hóuzi	cow – monkey
19.	母牛 mǔniú – 蝴蝶 húdié	cow – butterfly
20.	母牛 mǔniú – 兔子 tùzi	cow – rabbit
21.	母牛 mǔniú – 老虎 lǎohǔ	cow – tiger
22.	大象 dàxiàng – 熊猫 xióngmāo	elephant – panda
23.	大象 dàxiàng – 骆驼 luòtuo	elephant – camel
24.	大象 dàxiàng – 蜘蛛 zhīzhū	elephant – spider
25.	大象 dàxiàng – 蜜蜂 mìfēng	elephant – bee
26.	大象 dàxiàng – 狮子 shīzi	elephant – lion

27.	大象 dàxiàng – 猴子 hóuzi	elephant – monkey
28.	大象 dàxiàng – 蝴蝶 húdié	elephant – butterfly
29.	大象 dàxiàng – 兔子 tùzi	elephant – rabbit
30.	大象 dàxiàng – 老虎 lǎohǔ	elephant – tiger
31.	熊猫 xióngmāo – 骆驼 luòtuo	panda – camel
32.	熊猫 xióngmāo – 蜘蛛 zhīzhū	panda – spider
33.	熊猫 xióngmāo – 蜜蜂 mìfēng	panda – bee
34.	熊猫 xióngmāo – 狮子 shīzi	panda – lion
35.	熊猫 xióngmāo – 猴子 hóuzi	panda – monkey
36.	熊猫 xióngmāo – 蝴蝶 húdié	panda – butterfly
37.	熊猫 xióngmāo – 兔子 tùzi	panda – rabbit
38.	熊猫 xióngmāo – 老虎 lǎohǔ	panda – tiger
39.	骆驼 luòtuo – 蜘蛛 zhīzhū	camel – spider
40.	骆驼 luòtuo – 蜜蜂 mìfēng	camel – bee
41.	骆驼 luòtuo – 狮子 shīzi	camel – lion
42.	骆驼 luòtuo – 猴子 hóuzi	camel – monkey
43.	骆驼 luòtuo – 蝴蝶 húdié	camel – butterfly
44.	骆驼 luòtuo – 兔子 tùzi	camel – rabbit
45.	骆驼 luòtuo – 老虎 lǎohǔ	camel – tiger
46.	蜘蛛 zhīzhū – 蜜蜂 mìfēng	spider – bee
47.	蜘蛛 zhīzhū – 狮子 shīzi	spider – lion
48.	蜘蛛 zhīzhū – 猴子 hóuzi	spider – monkey
49.	蜘蛛 zhīzhū – 蝴蝶 húdié	spider – butterfly
50.	蜘蛛 zhīzhū – 兔子 tùzi	spider – rabbit
51.	蜘蛛 zhīzhū – 老虎 lǎohǔ	spider – tiger
52.	蜜蜂 mìfēng – 狮子 shīzi	bee – lion
53.	蜜蜂 mìfēng – 猴子 hóuzi	bee – monkey
54.	蜜蜂 mìfēng – 蝴蝶 húdié	bee – butterfly
55.	蜜蜂 mìfēng – 兔子 tùzi	bee – rabbit
56.	蜜蜂 mìfēng – 老虎 lǎohǔ	bee – tiger
57.	狮子 shīzi – 猴子 hóuzi	lion – monkey

58. 狮子 shīzi – 蝴蝶 húdié	lion – butterfly
59. 狮子 shīzi – 兔子 tùzi	lion – rabbit
60. 狮子 shīzi – 老虎 lǎohǔ	lion – tiger
61. 猴子 hóuzi – 蝴蝶 húdié	monkey – butterfly
62. 猴子 hóuzi – 兔子 tùzi	monkey – rabbit
63. 猴子 hóuzi – 老虎 lǎohǔ	monkey – tiger
64. 蝴蝶 húdié – 兔子 tùzi	butterfly – rabbit
65. 蝴蝶 húdié – 老虎 lǎohǔ	butterfly – tiger
66. 兔子 tùzi – 老虎 lǎohǔ	rabbit – tiger

Appendix 14 – Results of factor analysis

Before the factor analysis (FA) was performed an examination of the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was carried out to see if it was justifiable to carry out a FA on the correlation matrix. The obtained values were: (1) KMO = .599; (2) KMO = .665; (3) KMO = .626; (4) KMO = .809 for each of the four sets of variables and since all of the values were above 0.5 it was agreed that the sample was factorable.

Next, FA with an Equamax rotation was carried out on the four sets of data: (1) English language context of use; (2) Chinese language context of use; (3) language preference; and (4) English language proficiency, and only these factors that had Eigenvalues greater than 1 were retained. This procedure resulted in an eight-factor solution, i.e. the 1st component had 3 factors (2.082, 1.164, 1.077), the 2nd component had 2 factors (2.447, 1.136), the 3rd component had also 2 factors (2.138, 1.133), and the 4th component had 1 factor (3.760). Detailed information regarding the Eigenvalues greater than 1 is presented in the Table a below. The results of the Equamax rotation of the solution are shown in the four tables below (Table b, c, d, and e). Only those factor loadings that had values equal or greater than 0.30 were included.

component	initial Eigenvalues		
	total	**% of variance**	**cumulative %**
English language context of use			
1	**2.082**	34.701	34.701
2	**1.164**	19.396	54.097
3	**1.077**	17.945	72.043
Chinese language context of use			
1	**2.447**	40.779	40.779
2	**1.136**	18.929	59.708
language preference			
1	**2.138**	30.541	30.541
2	**1.133**	16.192	46.733
English language proficiency			
1	**3.760**	62.659	62.659

Table a. Eigenvalues greater than 1.0 recorded for eight factors

	component		
	1	2	3
context of English use – grandparents	**0.869**	-0.080	0.056
context of English use –parents	**0.777**	0.031	**-0.316**
context of English use – siblings	**0.652**	-0.066	0.271
context of English use –school	0.142	**0.899**	0.135
context of English use – church	**0.442**	**-0.629**	0.275
context of English use – friends	-0.010	0.020	**0.915**

Table b. Rotated component matrix based on the variables related to the context of English language use

As it can be seen from Table b, four variables load onto/correlate with factor 1, i.e. they have a value greater than 0.30 i.e. 0.869, 0.777, 0.652, and 0.442. These variables relate to the use of English with family members (grandparents, parents, siblings) and during church services. This factor was labelled “Personal English”. Furthermore, the two items (0.899 and -0.629) that loaded onto factor 2 were related to the use of English in more formal contexts, such as school and church, hence this factor was referred to as “Formal English”. Finally, two items (-0.316 and 0.915) that correlated with factor 3 related to the use of English with parents and friends. This last factor was labelled “Casual English”. The results obtained from the FA carried out on the first set of variables were used to exclude three participants from the study. That is, those participants who had high individual scores, which pointed to the English language dominance were omitted, because this feature was not sought in this project.

	component	
	1	2
context of Chinese use – parents	**0.916**	-0.053
context of Chinese use - grandparents	**0.863**	-0.163
context of Chinese use – friends	**0.715**	0.220
context of Chinese use – siblings	**-0.578**	0.125
context of Chinese use – school	-0.048	**0.793**
context of Chinese use – church	0.107	**0.646**

Table c. Rotated component matrix based on the variables in relation to the context of Chinese language use

It is clear from the Table c presented above that four items (0.916, 0.863, 0.715, and 0.578) loaded onto the first factor and two (0.793, 0.646) correlated with the second factor. The four items that loaded on factor 1 relate to the use of Chinese with family members (parents, grandparents, siblings) and friends and hence this factor was named "Personal Chinese". The second factor is referred to as "Formal Chinese" as the two items that correlated with it pertained to the use of Chinese language in a more formal context, such as school and church. Based on the information gathered from this stage of the analysis, another three participants were removed from the study. That is, the obtained individual scores indicated that the participants used Chinese in a limited context, which did not point to Chinese language dominance.

	component	
	1	2
language used to think in	**0.727**	0.164
language used most of the time	**0.720**	0.015
language used to do simple math	**0.641**	0.088
language used to read books	**0.410**	**0.401**
language preference in general	0.060	**0.791**
language used to understand humor better	0.056	**0.735**
language used to watch TV	0.122	**0.512**

Table d. Rotated component matrix based on the variables related to the language preference

We can read from Table d that four items (0.727, 0.720, 0.641, 0.410) correlated with the first factor they all related to the preference of language use for performing higher-order mental abilities (thinking, doing mental maths, and reading). This factor was labelled "Language of Thought". Another four items (0.401, 0.791, 0.735, 0.512) loaded onto factor 2, and they related to the preference of language use for general purposes and entertainment (reading books, understanding humour, and watching TV). This factor was named "Language of Entertainment". This part of the analysis allowed for the exclusion of a further four data sets from four participants. That is, the obtained individual scores indicated that the participants preferred using English language for both thinking and entertainment, hence those participants were considered as not being suitable.

	component
	1
ability to understand spoken English	**0.797**
ability to understand written English	**0.821**
ability to speak in English	**0.815**
ability to write in English	**0.828**
ability to read in English	**0.821**
ability to use grammar in English	**0.653**

Table e. Component matrix based on the variables related to English language fluency (since only one component was extracted, it was not possible for the solution to be rotated)

Table e presents one factor with all six items (0.797, 0.821, 0.815, 0.828, 0.821, 0.653) loading onto it. The factor was labelled “General English”. Based on the information obtained form the FA performed on this set of variables, a decision was made not to discard any data sets, since the participants judged their English language fluency similarly, i.e. on a 24 point cumulative scale, the average score was M=17.6 (SD=2.8).

Appendix 15 – Multidimensional scaling analysis

In order to run an MDS analysis, data must be entered in a particular matrix fashion in SPSS. Hence, in this study, to start with, the individual similarity judgments collected from each participant were entered into SPSS into a 12x12 matrix having a lower triangular shape (an example of a matrix is presented in the Table below). The 12 rows and 12 columns were labelled by the animal terms (ant, cow, elephant, panda, camel, spider, bee, lion, monkey, butterfly, rabbit, and tiger). Next, to obtain the semantic structure, all data was stacked into a single matrix and a correspondence analysis was carried out, which in turn produced a MDS representation of the data (the MDS analysis performed in this study followed a similar procedure conducted by Romney et al., 1997.

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1 : id AHJ Visible: 14 of 14 Varial

	id	ant	cow	elephant	panda	camel	spider	bee	lion	monkey	butterfly	rabbit	tiger	name
1	AHJ	.	.	.	.	.	.	.	.	.	.	.	.	ant
2	AHJ	6	.	.	.	.	.	.	.	.	.	.	.	cow
3	AHJ	6	2	.	.	.	.	.	.	.	.	.	.	elephant
4	AHJ	6	3	3	.	.	.	.	.	.	.	.	.	panda
5	AHJ	6	3	1	3	.	.	.	.	.	.	.	.	camel
6	AHJ	2	5	5	5	5	.	.	.	.	.	.	.	spider
7	AHJ	1	6	6	5	5	2	.	.	.	.	.	.	bee
8	AHJ	6	2	3	2	2	5	6	.	.	.	.	.	lion
9	AHJ	4	3	3	3	3	5	5	3	.	.	.	.	monkey
10	AHJ	3	5	5	5	5	2	1	6	5	.	.	.	butterfly
11	AHJ	3	5	4	4	4	3	4	3	2	3	.	.	rabbit
12	AHJ	6	2	2	3	2	5	6	6	3	6	3	.	tiger

To produce individual conceptual maps (presented in chapter four, section 4.2) the following procedures were followed:

- Figure 37 - 67 (12x12) matrices were stacked into a single matrix, resulting in 804 (12x67) rows and 12 columns. The averaged Kruscal Stress value over the matrices was equal to 0.32939.

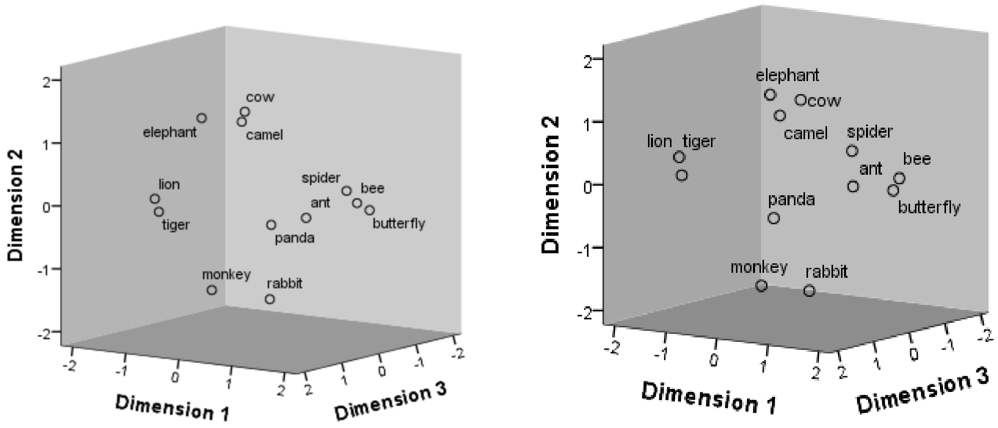
- Figure 38 – 18 matrices were combined into one (18x12=216 rows and 12 columns). The averaged Kruscal Stress value for this set of data was established to be 0.24164.

- Figure 39 – 15 matrices were stacked on top of each other, which resulted in one matrix of 15x12=180 rows and 12 columns. The averaged Kruscal Stress value for this map was 0.28502.

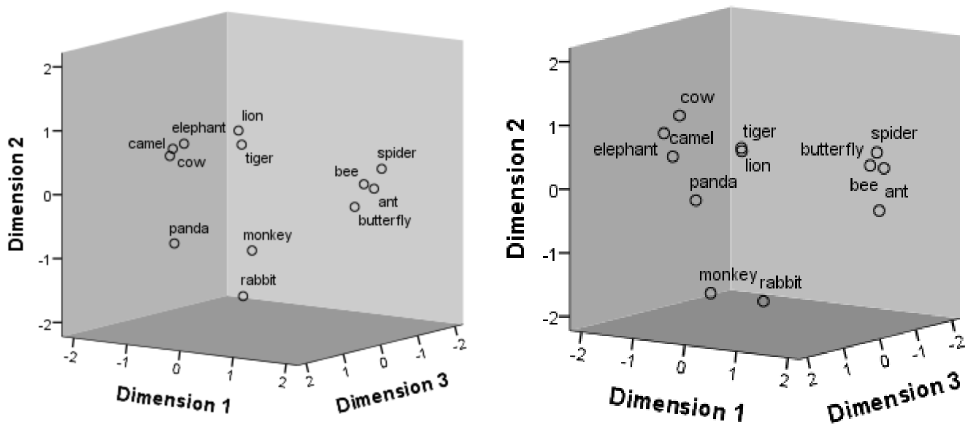
- Figure 40 – 20 individual matrices were stacked on top of each other to produce the final matrix, which consisted of 20x12=240 rows and 12 columns. The averaged Kruscal Stress value was calculated to be 0.34449.

- Figure 41 – It was produced by compiling 14 matrices together, which gave one matrix of 14x12=168 rows and 12 columns. The averaged Kruscal Stress value was estimated to be 0.39861.

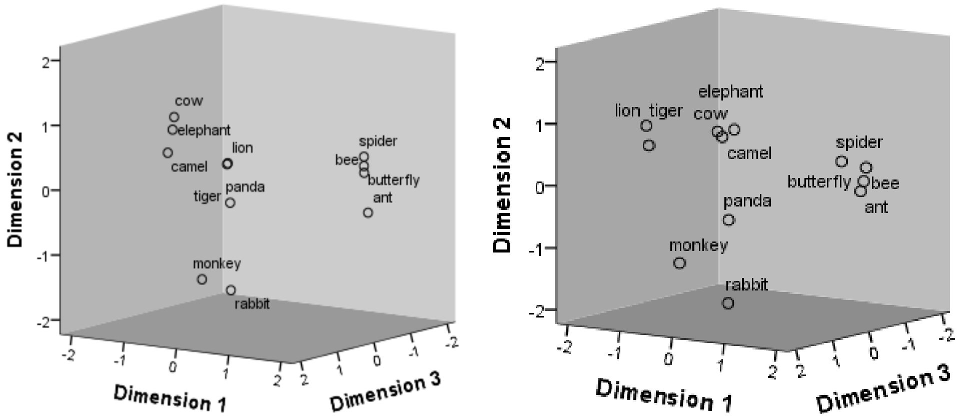
Appendix 16 – Three and four dimensional MDS solutions



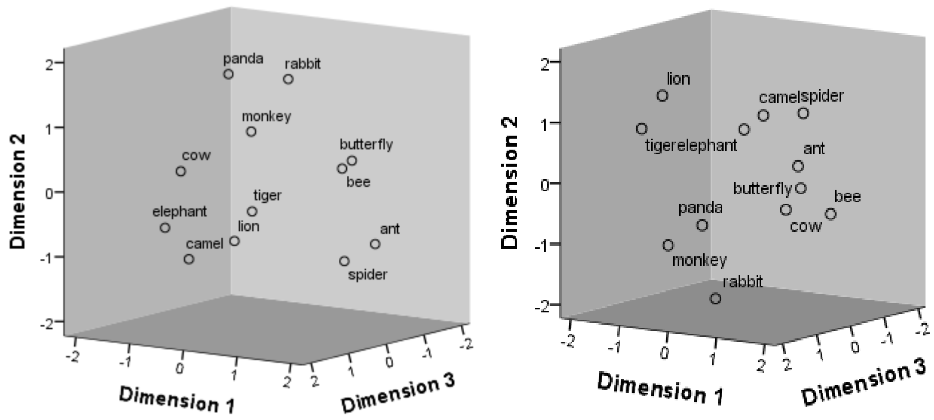
a) Three (left map) and four (right map) dimensional maps for all participants. Kruskal's stress for a three dimensional map is equal to 0.25123; in four dimensions it amounts to 0.20376.



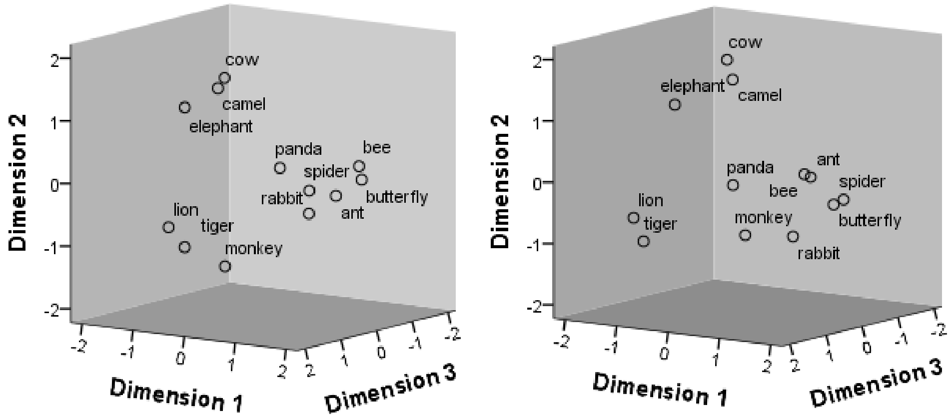
b) Three (left map) and four (right map) dimensional maps for bilinguals who provided responses in Chinese. Kruskal's stress for a three dimensional map is equal to 0.22257; in four dimensions it amounts to 0.1794.



c) Three (left map) and four (right map) dimensional maps for bilinguals who provided responses in English. Kruskal's stress for a three dimensional map is equal to 0.21799; in four dimensions it amounts to 0.16776.



d) Three (left map) and four (right map) dimensional maps for Chinese monolinguals. Kruskal's stress for a three dimensional map is equal to 0.26514; in four dimensions it amounts to 0.19585.



e) Three (left map) and four (right map) dimensional maps for English monolinguals. Kruskal's stress for a three dimensional map is equal to 0.25181; in four dimensions it amounts to 0.21163.

Appendix 17 – Results of additional analysis of variance with language proficiency as a covariate

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Since it is possible that language proficiency is a confounding factor but only in one language direction, i.e. either in the L1 to L2 direction or L2 to L1 one, the two conditions were looked at separately. A repeated measures ANOVA was run twice using the language proficiency (the exact scores) as a between subject variable. The results, which are collated in the two Tables below, were not statistically significant.

factor	df	F	Sig.
		within	
prime relatedness	1	.022	.882
prime relatedness * language proficiency	8	.195	.990
		between	
language proficiency	8	1.132	.362

Table A – Significance values from the analysis performed on the L2 to L1 condition

factor	df	F	Sig.
		within	
prime relatedness	1	24.298	.000
prime relatedness * language proficiency	8	.543	.847
		between	
language proficiency	8	.536	.852

Table B – Significance values from the analysis performed on the L1 to L2 condition

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